PUBLIC LIBRARY OF THE

SCIENTIFIC AMERICAN

No. SUPPLEMENT 367

Scientific American Supplement, Vol. XV., No. 367. Scientific American, established 1845. | NEW YORK, JANUARY 13, 1883. | Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

NEW STATUE OF COLUMBUS.

We are indebted to *La Ilustració Catalana* for our engraving of a new statue of Christopher Columbus which has lately been erected in the grounds in front of the buildings of the Ministry of Foreign Affairs in Madrid. It is the design of Gayetá Buigas, and is highly spoken of as a work of art.

Columbus was born in 1435 or 1445—the exact year unknown—at Genoa, Italy. April 17, 1492, he signed the famous agreement between Ferdinand and Isabella of Spain, in which the monarchs stipulated that he and his heirs forever should hold the office of Admiral over all lands that he might discover; that he should be viceroy and governor-general of the same; that he should have one-tenth of all gold, silver, precious stones, spices, and merchandise that from them might be obtained; that in case of disputes he should be the sole judge between himself and Spain. On Friday, August 3, 1492, he set sail from Palos, Spain, with three vessels, of which the largest, the Santa Maria, was 90 feet long. In all, 120 men comprised the three companies. At 2 A.M., Oct. 12, 1492, land was discovered by a seaman, although a light on shore had first been seen by Columbus himself at 10 P.M. of the night previous. The land discovered was the island of San Salvador, one of the West India Islands—the first coast seen in the New World. Columbus returned to Spain, March 15, 1493. The Spanish sovereigns received him with the greatest honors, and solemnly confirmed their agreement with him. A large and new fleet of 17 ships, and 1,500 men, was given him, and many new discoveries followed. Subsequently he made another voyage with six ships, and discovered the Orinoko River in South America, and other coasts. Returning to the West Indies, he was there arrested and carried a prisoner to Spain by order of King Ferdinand, who grossly violated his compact, having become jealous of the fame and fortune of his favorite. Columbus died at Valladolid, Spain, May 20, 1506, poor and forlorn, robbed and disgraced by the sovereign who had made him such solemn promises, and to whom he had given a new world. His body was taken in 1536 to San Domingo, and thence removed to Havana, Cuba, in 1796, where it now rests. In personal appearance Columbus was tall, slender nose, gray-blue eyes, fresh complexion, auburn hair. He had a noble appearance; in habits, temperate, in disposition, affectionate. His son and daughters lived to enjoy great wealth and prosperity.

STATUE OF CHRISTOPHER COLUMBUS, LATELY ERECTED IN MADRID.

ALASKA.*

By SHELDON JACKSON, D.D.

To say that Alaska contains 580,107 square miles gives no adequate conception of its great size. That impression is better secured by a series of relative comparisons. For instance, from extreme north to south is 1,400 miles in an air line, or as far as from Maine to Florida; and from its eastern boundary to the end of the Aleutian Islands, 2,200 miles in an air line, or as far as from Washington to California.

The island of Attu, at the end of the Aleutian chain, is as far west of San Francisco as Maine is east; so that between the extreme eastern and western sections San Francisco is the great central city.

Or take another basis of comparison: Alaska is as large as all the New England and Middle States, together with Ohio, Indiana, Illinois, Wisconsin, Michigan, Kentucky, and Tennessee combined, or as large as all the United States east of the Mississippi River and north of Georgia and the Carolinas, or nearly one-sixth of the entire area of the United States. It has a coast line of 25,000 miles, or two and a half times more than the Atlantic and Pacific coast lines of the remaining portion of the United States. The coast of Alaska if extended in a straight line would belt the globe. Commencing at the north shore of Dixon Inlet, in latitude 54° 40', the coast sweeps in a long regular curve north and west to the entrance of Prince William's Sound, a distance of 550 miles; thence 725 miles south and west to Unimak Pass, at the end of the Aliaska Peninsula. From this pass the Aleutian chain of islands sweep 1,075 miles in a long curve almost to Asia, the dividing line between Russia and the United States being the meridian of 193° west longtitude. North of Unimak Pass, the coast forms a zigzag line to Point Barrow, on the Arctic Ocean, and thence south of east to the boundary.

Alaska is the great island region of the United States, having off its southeastern coast a large archipelago. The 732 miles of latitude from Puget Sound to the head of Lynn Channel contain a remarkable stretch of inland ocean navigation, noted for its bold shores, deep water, numerous channels, innumerable bays and harbors, abundance of fuel and fresh water, and shelter from the swells of the ocean.

The southern portion of this great archipelago is in Washington Territory, the central portion in British Columbia, and the northern portion in Alaska. The portion in Alaska has been named the Alexander Archipelago. It is about 300 miles north and south and 75 miles wide, and is variously estimated to contain from 1,000 to 10,000 separate islands. The aggregate area of these islands is 14,149 square miles.

Six hundred miles to the westward is the Kadiak group, aggregating 5,676 miles; then the Shumagin group, containing 1,081 square miles, and the Aleutian chain, with an area of 6,391 square miles. To the northward is the Pribyloff group (seal islands), containing, with the other islands in Behring Sea, 3,968 square miles.

The total area of the islands of Alaska is 31,205 square miles, which would make a State as large as the great State of Maine.

It is the region of the highest mountain peaks in the United States. The Coast Range of California and the Rocky Mountain Range of Colorado and Montana unite in Alaska to form the Aliaskan Mountains. This range, instead of continuing northward to the Arctic Ocean, as the old atlases represent, turns to the southwestward, extends through and forms the Aliaska Peninsula, and then gradually sinks into the Pacific Ocean, leaving only the highest peaks visible above the water. These peaks form the Aleutian chain of islands. The islands decrease in size, height, and frequency as the mountain range sinks lower into the ocean. Unimak, the most eastern of the chain, has that magnificent volcano Shishaldin, 9,000 feet high; then Unalashka, 5,691 feet; next Atka, 4,852 feet; then Kyska, 3,700 feet; and Attu, the most western of the group, only 3,084 feet high.

In the Aliaskan Range are the highest peaks in the United States: Mount St. Elias, 19,500 feet high; Mount Cook, 16,000 feet; Mount Crillon, 15,900; Mount Fairweather, 15,500, and numerous others. In addition to the Aliaskan Range, are the Shaktolik and Ulukuk Hills, near Norton Sound; the Yukon and Romanzoff Hills, north of the Yukon River; the Kaiyuh and Nowikakat Mountains, east and south of the river, and a low range of hills bordering the Arctic coast.

Alaska contains the great volcanic system of the United States. Grewingk enumerates sixty-one volcanoes, mainly on the Aliaska Peninsula and Aleutian Islands, that have been active since the settlement by Europeans.

It is the great glacier region. From Bute Inlet to Unimak Pass nearly every deep gulch has its glacier, some of which are vastly greater and grander than any glacier of the Alps.

On Lynn Channel is a glacier computed to be 1,200 feet thick at the "snout" or lower projection. In one of the gulches of Mount Fairweather is a glacier that extends fifty miles to the sea, where it ends abruptly in a perpendicular ice wall 300 feet high and eight miles broad. Thirty-five miles above Wrangell, on the Stikine River, between two mountains 3,000 feet high, is an immense glacier forty miles long and at the base four to five miles across, and variously estimated from 500 to 1,000 feet high or deep.

Alaska abounds in hot and mineral springs. According to Dall, there are large ones south of Sitka; also on Perenosna Bay, on Amagat Island, and Port Moller. On Unimak Island is a lake of sulphur. Near the volcano Pogrumnoi are hot marshes. Boiling springs are found on the islands Akhun, Atka, Unimak, Adakh, Sitignak, and Kanaga.

* From an address before the National Education Association, at Washington, March, 1882.

These latter have for ages been used by the natives for cooking food. In the crater of Goreloi is a vast boiling, steaming mineral spring, eighteen miles in circumference. A lake strongly impregnated with niter is found on Beaver Island. The thermal springs on the island of Unalashka hold sulphur in solution.

The northern portion of the Territory, within the Arctic Circle, is famous for its beautiful auroral displays.

Alaska contains one of the largest rivers of the United States. The river Yukon is 70 miles wide across its five mouths and intervening deltas. At some points along its lower course one bank cannot be seen from the other. For the first thousand miles it is from one to five miles wide, and in some places, including islands, it is 20 miles from main bank to main bank. Navigable for 1,500 miles, it is computed to be 2,000 miles long.*

The other principal rivers of the Territory are the Stickine, 250 miles long; the Chilkat; the Copper; the Fire; the Nushergak, a large shallow stream 150 miles long; the Kooskovime, next to the Yukon in size, and between 500 and 600 miles long; the Tananah, 250 miles (this river is half a mile wide at its mouth, with a very strong current); the Nowikakat, 112 miles; and the Porcupine. The last three are tributaries of the Yukon. The only river of any size flowing into the Arctic Ocean is the Colville, for a long time supposed to be the outlet of the Yukon.

PRODUCTS OF ALASKA.

Alaska is rich in material resources.

The chief value of Alaska to Russia was its wonderful fur supplies; and when the Territory was sold to the United States, the most prominent attraction was the seal fur fisheries on the Pribyloff group of islands, in Behring Sea. To protect these valuable interests, the Government leased these islands for twenty years to an incorporated company known as the "Alaska Commercial Company." They pay the Government an annual rental of $55,000 for the islands and a royalty of $262,500 a year on the 100,000 seal skins allowed by law to be taken.

Thus these two little islands—St. Paul, 13 miles long and 6 wide, and St. George, 10 miles long and 6 wide—furnish nearly all the seal skins used in the markets of the world, and have paid a revenue into the United States Treasury from 1871 to 1882 of over three million dollars; and yet it is thought by some that Alaska was a worthless purchase.

The Alaska Company has a number of trading stations in addition to its seal fisheries.

The next most valuable fur is that of the sea otter. In 1880 these skins were quoted at from $30 to $200 each.

The principal land fur bearing animals are the several varieties of the fox, the mink, beaver, marten, lynx, otter, bear, and wolverine. There are also the skins of the whistler, reindeer, mountain goat and sheep, ermine, marmot, muskrat, and wolf.

The waters and coast of Alaska abound in fish. Every naval or scientific expedition, from the time that Captain Cook in circumnavigating the globe visited those waters to the present time, has not failed to report the great quantities of salmon, cod, herring, halibut, mullet, ulikon, and other fish of commerce.

Cod are found from the Seal Islands southward, but are most abundant on the banks in the Kadiak and Aleutian Archipelagoes. Three San Francisco firms engaged in the business caught 3,000 tons during 1879 on the banks off the Shumagin Islands.

Alaska can also supply the world with salmon, herring, and halibut of the best quality. Salmon canneries have been established near Sitka, at Klawak, and at Kasa-an Bay.

Alaska is the great reserve lumber region of the United States. It is only a question of a few years when the forests of Maine, Michigan, Wisconsin, Minnesota, and even Puget Sound will be denuded of their best timber. Then the country will appreciate those thousands of square miles of yellow cedar, white spruce, hemlock, and balsam fir that densely cover the southeastern section of Alaska.

The indications are that Alaska is very rich in minerals. Coal is found all along the coast. The most valuable of the known deposits are found in Cook's Inlet. Coal has also been taken and used by the United States revenue marine steamer Corwin from the Arctic coast.

Petroleum is found floating on a lake near the Bay of Katmai. It is quite odorless, and in its crude state has been used by the Russians for lubricating machinery. Large deposits have also been found on Copper River.

Specimens of pure copper have been found in many places. It is so abundant on Copper River as to give its name to that stream. At Kasa-an Bay a valuable mine of bronze copper is being worked by an English company. Lead in small quantities is found on Whale Bay, south of Sitka, and also in Kadiak Island.

Iron is common to many sections of the Territory. Graphite is found at several places. A fine quality of marble exists in inexhaustible quantities. A fine quality of bismuth is found on Vostovia Mountain. Kaolin, fire clay, and gypsum are also found. Sulphur exists in large quantities. Amethysts, zeolites, garnets, agates, carnelians, and fossil ivory are found. Indeed, the people of the United States have no conception of the mineral wealth of Alaska.

Gold is found in a number of places, and supposed to exist in many others. Up the Stikine River, through Alaska, over on the headwaters of Deese River, are the Cassiar mines of British Columbia, where from 2,000 to 3,000 miners have spent several summers in placer mining. The annual product of these mines has been from $800,000 to $1,000,000.

During 1881 gold mines, both placer and quartz, were opened on Gastineaux Channel, opposite Douglass Island, Alaska, where the American town of Juneau was built. The yield for the first summer was over $30,000.

CLIMATE.

In a country as extended as Alaska, with its large rolling plains, wide valleys, and high mountains, there is necessarily a wide diversity of climate. In a general way, it may be said that inland Alaska has an Arctic winter and a tropical summer. At Fort Yukon the thermometer often rises above 100° in summer, and indicates from 50° to 70° below zero in winter. At Nulato, on the Yukon River, the fall of snow during the winter averages 8 feet and frequently reaches 12 feet. Along the immense southern coast and islands the climate is moist and warm.

The greatest cold recorded on the island of Unalashka, by a Greek priest, during a period of five years, was zero of Fahrenheit; extremest heat for the same time was 77°. The average for five years, at 7 A.M., was 37°; 1 P.M., 4 °; and 9 P.M., 36°. The average of weather for seven years was 53 all clear days, 1,263 half clear, and 1,235 all cloudy. It is very much the climate of Northwestern Scotland.

At St. Paul Harbor, Kadiak Island, the mean annual summer temperature is 54°, and winter 29°, the coldest month February, with the thermometer at 27°; and the warmest, July and August, with a mean temperature of 57°, the extremes being from 6° to 75°. The climate is that of Southern Sweden and Norway. The annual rainfall is about 73 inches.

At Sitka, where, with the exception of a few short gaps, a record of the thermometer has been kept for 45 years, it has been found that the mean spring temperature was 41·2°; summer, 54·6°; autumn, 44·9°; winter, 32·5°; and for the entire year, 43·3°. The greatest degree of heat recorded in these 45 years was 87·8°, and of cold 4° below zero. The thermometer has recorded below zero during only four of the 45 years, and above 80° during only seven of those years. The mean annual temperature for 45 years has ranged from 41·3° to 46·8°, a difference of but 5·5°. The annual rainfall was 81 inches.

During a period of 43 years there has been an average of 200 rainy or snowy days a year, the most favorable year being 1833, with 82 rainy and 33 snowy days, and the most unfavorable 1856, with 258 rainy and 27 snowy days.

From these facts, taken from the Alaska *Coast Pilot*, Appendix 1, Meteorology, A.D. 1880, the surprising fact is brought to light that the winter climate of Southeastern Alaska for 45 years past has been the average winter climate of Kentucky and West Virginia and the average summer climate of Minnesota.

This mild climate of Southern Alaska is due to the warm Japan current of the Pacific, the Kuro-Siwo, which first strikes the American continent at the Queen Charlotte Islands, in latitude 50° north. Here the stream divides, one portion going northward and westward along the coast of Alaska and the other southward along the coast of British Columbia, Washington, Oregon, and California, giving them their mild winter climate.

The former stream, flowing northward, has been named "the Alaska current," and gives the great southern coast of Alaska a winter climate as mild as that of one-third of the United States.

The physical configuration of Alaska naturally divides it into three districts: the Yukon, extending from the Alaskan range of mountains to the Arctic Ocean; the Aleutian, embracing the Aliaska Peninsula and islands west of the one hundred and fifty-fifth degree of longitude; and the Sitkan, including Southeastern Alaska.

Concerning the Yukon district but little is known, except on the coast and along the Yukon River.

The *Coast Pilot*, a publication of the United States Coast Survey, represents the country between Norton Sound and the Arctic Ocean as "a vast moorland, whose level is only interrupted by promontories and isolated mountains, with numerous lakes, bogs, and peat-beds. Wherever drainage exists, the ground is covered with a luxuriant herbage, and produces the rarest as well as most beautiful plants. The aspect of some of these spots is very gay. Many flowers are large, their colors bright, and though white and yellow predominate, other tints are not uncommon. Summer sets in most rapidly in May, and the landscape is quickly overspread with a lively green." The extreme heat and constant sunshine cause it to produce rank vegetation. The commercial value of this section is mainly in its furs.

The Aleutian district is largely mountainous and of volcanic formation. Between the mountains and the sea are, however, many natural prairies, with a rich soil of vegetable mould and clay, covered with perennial wild grasses.

This district, except at the eastern end, is without timber larger than a shrub. The principal resource at present is in the wonderful fisheries off its coast.

The Sitkan district is mountainous in the extreme, and the larger portion covered with dense forests. The great wealth of this district is in its lumber, fish, and minerals. Many garden vegetables are raised with success.

With regard to Alaska, Mr. William H. Dall, of the Smithsonian Institution, writes, after a trip to Europe: "I come back convinced, from personal inspection, that Alaska is a far better country than much of Great Britain and Norway, or even part of Prussia."

MEANS OF COMMUNICATION.

The routes of travel to Alaska are not very numerous. A steamer carrying the United States mail between Port Townsend, Washington Territory, and Fort Wrangell and Sitka, Alaska, makes a monthly trip.

Two small steamers run at irregular intervals during the summer from Victoria, B. C., to Fort Wrangell, calling *en route* at the several trading posts on the coast of British Columbia.

The country west of Sitka, including the Aleutian Islands and the great interior and main section of the Territory, is reached from San Francisco; so that a citizen of Oregon, in order to reach Kadiak, Unalashka, the seal islands, St. Michael, or the numerous villages on the Yukon River, is under the necessity of going by the way of San Francisco. From this latter place there is frequent communication with Western Alaska, and once a year with the central and northern sections.

POPULATION.

The census of 1880 gives the following enumeration: Yukon division, 7,000; interior division, 2,226; Kuskokwim, 3,654; Bristol Bay, 4,340; Kadiak, 2,606; Kenai, 984; Belkovsky, 669; Unalashka, 1,393; islands in Behring Sea, 1,290; Prince William Sound, 500; and Southeastern Alaska, 6,725; making 31,386, of whom about 18,000 are supposed to be Eskimo or Innuit. In addition to the above are about 1,500 whites in Southeastern Alaska, mainly traders and miners.

The Aleutian population and a portion of the Innuits were so far brought under the influence of the Russians that they became civilized, and are living after European methods. Among these the Greek Church of Russia claims from 8,000 to 9,000 members.

The remaining Innuit and Indian population are largely in their original condition.

* Since making this address, I have received a copy of a letter written by Robert Campbell, of the Hudson's Bay Fur Company, to Hon. M. C. Butler, United States Senate, in which Mr. Campbell represents the Yukon and its tributary Pelly as navigable at certain seasons nearly 3,000 miles. Mr. Campbell says: "In the spring of 1840 . . . I crossed the mountains and came on the headwaters of a magnificent stream, which I named the 'Pelly River.' . . . In 1850 I received permission to explore the Pelly down to its mouth, . . . in due time reaching Fort Yukon, . . . setting the question at rest that the Pelly and Yukon were one and the same river. . . . Three kinds of salmon ascend the river as far as Pelly Banks, which is about *three thousand miles* from seacoast. . . . *When its [ice] crusts [on] in summer, steamers could ascend to within thirty miles of Pelly Banks.*"

REVOLUTION IN COAL HAULING.

The *Osceola Reveille* has the following: Having heard so much of the newly contrived plan of Mr. C. B. Finley, the superintendent and mining engineer of the Kittanning Coal Company, at the Franklin collieries, for hauling the coal from the mines; and having been frequently told by those who have seen it and who take interest in such things, of the simplicity of its arrangement, the comparatively trifling cost of its construction, and its wonderful effectiveness, we were curious to see it in motion ourselves, and with this intent we visited the "Smiley" drift of this work, one day last week, and had the plan, the gearing, and the whole *modus operandi* of the machine exhibited and explained to us by Mr. Finley, the inventor, patentee, and manager himself.

Commencing at the mouth of the drift, a side track has been built parallel with the main track and connecting with the same about 100 or 150 feet away from the drift mouth. At the mouth of the drift, and under the main track, are two drums, about 2½ or 3 feet in diameter, around which a three-quarter inch wire rope is taken, carried into the bank, some 1,200 feet, to the place where trains are made up from the different rooms with mules, where it passes around another huge drum or pulley, and returns to the drum at the mouth of the drift, being a continuous chain. Here, after the train is coupled up (there were 26 cars in the one we saw hauled out, but it has brought 40) the hindmost car of the train, which is astride of the rope, is clamped to it, and in this manner it pushes the others before it, and in this particular it differs from the rope used at the Moshannon colliery, which is fastened to either end of the train. One of the drums under the main track at the mouth of the drift has a shaft passing through it, on the one end of which, and right between the two tracks, is a large cog wheel. Passing under the side track are two other shafts with two friction wheels upon either, and with smaller cog wheels upon the end of each to fit into front and rear of the big cog wheel on the shaft from the drum. Space is made in the rails to allow the four friction wheels to protrude to a level with the rails, and spaced so as to fit directly under the four driving wheels of the locomotive when it is in place for operation. When everything is in readiness to bring a train out, the locomotive is switched off on the siding, run up on the four friction wheels, where it makes itself fast by a spring at the front, and like an old farm horse on a horse power thrashing machine, it treads the train from its dark recess to the light of day; and this is all there is about this wonderful and much talked of, yet simple, unassuming, and effective contrivance, which has been giving the best of satisfaction to those who have its services, ever since it was put in motion, some four or five months since. A train of forty cars can be brought by this machine from the parting where the trains are made up to the mouth of the drift in three minutes, the locomotive weighing but eight tons and a quarter.

When the rear end of the train has reached the mouth of the drift, the engineer by a wire which is at easy reaching distance, disconnects the locomotive from where it had fastened itself, and away it scuds down and out on to the main track, takes hold of the front end of the train, and pulls it to the dump some six or eight hundred feet farther away. An indicator with a hand something like that of a clock or steam-indicator is placed at the mouth of the drift to note the progress of the train on its ingress, or egress, operated by the motion of the friction wheels; alarm bells are also so arranged as to warn the engineer when to stop, back, or go ahead, by persons in the bank. Mr. Finley informed us that they were soon going to erect an electric telegraph for the purpose that would be still more convenient and satisfactory than the alarm bells. The advantages claimed by this arrangement over the stationary engines for hauling cars by endless chains are many; the paramount one is that while the trains are being made up in the bank, which consumes considerable time, the engine can be used for other purposes, at other places. Mr Finley deserves great credit for his ingenuity, and has added much to the producing of coal by the perfecting of this simple and effective machinery in this advanced age of the business. What surprises Mr. Finley the most about his new-fangled arrangement, as well as ourselves, is that the locomotive has developed more power while on the friction wheels than on the rails. It can haul out but fifteen cars by the one way and forty by the other.

THE FASTEST TRAINS IN EUROPE AND AMERICA.*

By A. L. ROTCH.

I SHALL first consider American trains, taking into account the acceleration which has occurred within the last few years. For England, my data are brought down to 1880, and on the Continent it is as old as 1878; but generally speaking, the figures are sufficiently accurate to-day to admit of comparisons.

AMERICA.

The fastest trains in the United States are in the East, and are those between Jersey City and Philadelphia, Boston and New York, and one from New York to Albany. In selecting representative trains, I have given preference to those which maintain the highest speed for the longest time. Probably the fastest train in this country, and one which is little below the speed of the fastest English trains for the same distance, is the Philadelphia express, on the Pennsylvania Railroad, which leaves Jersey City at 4:8 P.M., and makes the run of 88·4 miles in 1 hour 52 minutes, including three stops, or at the rate of 47·8 miles per hour. Jersey City to Germantown Junction, 84·2 miles, is run in 1 hour 41 minutes, including one stop, or 50·5 miles per hour. I timed last winter the fastest train east, whose schedule time is 1 hour 59 minutes. It was then, however, 6 minutes late, and as it was bulletined "on time," perhaps it seldom does better. The train consisted of six cars, one of them a Pullman. A stop was made at Germantown Junction, and it was some time before a high speed was attained. The fastest miles were run in 63 seconds each, or 57 miles per hour; 21 miles were made in 25¾ minutes, or 49 miles per hour. The 84·2 miles from Germantown Junction to Jersey City were run in 1 hour 52¼ minutes = 45 miles per hour, including slackening through several towns. It may here be said that the Pennsylvania road bed equals that of any foreign road I have seen, while the freedom of the train from oscillation and vibration was remarkable. This train used to run in five minutes less time, and the fast train west was two minutes quicker when started a few years ago, so perhaps it was found impossible to maintain these higher speeds.

The Bound Brook route of the Philadelphia & Reading

* Paper read before the E. M. E. Society of the Massachusetts Institute of Technology, Dec. 5, 1882.

Railroad has a train from Philadelphia to Jersey City, 89·4 miles, in 1 hour 57 minutes, including five stops, or 45·8 miles per hour. Wayne Junction to Jersey City, 85·1 miles, is run in 1 hour 47 minutes, including three stops, which is 47·7 miles per hour.

The 4:30 P.M. train from New York to Boston *via* Springfield is the fastest between the two cities, taking 6 hours 3 minutes for the 234 miles. I timed the train last September when it was on time. The engines were of the ordinary type with about 5 ft. 6 in. drivers, and the train consisted of six cars, two of them being parlor cars. On the New Haven Division, the fastest runs were 1·90 miles in 2 minutes = 57 miles per hour; 1·73 miles in 1 minute 55 seconds = 54·5, and 3 miles in 3 minutes 15 seconds=53 miles per hour. Owing to the Connecticut law requiring a stop at every drawbridge, the time for the 73¼ miles between New York and New Haven, including six stops, was 1 hour 54¾ minutes, or only 38·5 miles per hour. The 62 miles between New Haven and Hartford were made in 1 hour 30¼ minutes, including two stops, or 41·5 miles per hour; average speed while running, 43·8 miles per hour. On the Boston & Albany, 96 miles (Springfield to junction of Brookline Branch, Boston) were run in 2 hours 20½ minutes, including three stops, or 41 miles per hour; running speed, 43·1 miles per hour, excluding stops. The time for the trip of 234 miles was 5 hours 30 minutes, and the speed 42·5 miles per hour.

The Shore Line express makes its run to Stonington, 93 miles, in 2 hours 1 minute, including a stop at Providence, or over 46 miles per hour. As long ago as 1878, the *Railroad Gazette* said: "For over two years a daily train has been run over the 43½ miles between Boston and Providence in one hour, including a dead stop at the crossing, a 6-mile grade over Sharon Hill of 35 feet to the mile, a slowing up at Mansfield and through Pawtucket over a mile, and a slacking over three bridges. The engines have 5½ feet drivers and 17-inch cylinders. The train is a baggage and smoker, and there are sometimes four 24-ton passenger and a 32-ton Pullman." In February, 1881, I timed this train as follows: Left crossing, 1:3 P.M. Beyond Foxboro the speed was a mile in 63 seconds, or 57 miles per hour; 2·48 miles were run in 2 minutes 40 seconds=55·5 miles per hour. Before reaching Pawtucket, 14·9 miles had been run in 17½ minutes= 54·5 miles per hour. Providence was reached at 1:59 P.M.= 45 miles per hour. From the crossing the speed was 47 miles per hour. Last June this train was quickened beyond Providence as above.

The fastest train on the New York Central Railroad is the Chicago & Lake Shore special, which runs to Albany, 140 miles, without a stop at the rate of 49·5 miles per hour. The first 58¾ miles are made in 1 hour 28 minutes.

These figures should, I think, be sufficient to show that regular trains in this country seldom run a mile in 60 seconds. The fastest run which I have made here was on the New York & New England Railroad the other day, when, on a down grade beyond Bolton Notch, 4 miles were covered in 4 minutes 10 seconds, or 58 miles per hour. In England I have been faster, and it is said, on authority, that it is not uncommon for English express trains to make 60 or 70 miles per hour when running on their schedule time. It has been said that it is impossible for an engine with a 5½ foot driver to make a mile in a minute. Mr. Le Van gives the greatest piston speed as about 1,200 feet per minute, which would give about 59 miles per hour with such a wheel. On the Pennsylvania the fast train engines had two pair of drivers 68 inches in diameter, and had to make 300 revolutions to make a mile a minute. Coupled drivers are said to be dangerous at high speeds from the liability of the parallel rods to break, and such accidents have recently happened. Still, in late years, large coupled wheels have been much used on English and Continental express engines.

When in Europe during 1877–78, I looked up the fastest trains in the several countries, and as I traveled by some of them I further noted their maximum speeds. A few general remarks about European railways may be interesting. The Continental railways are partly controlled by the governments. They are well built, with curves of large radius. Instead of cars there are carriages, divided into compartments holding six or eight persons. They do not, as a rule, have bogie trucks, but their small wheel base enables them to pass round the curves. There are three or four classes of passengers. Generally, first and second class are carried by the express trains, but in France only first class are taken, and a higher fare charged. The locomotives often have only a single pair of drivers, 7 feet or so in diameter. In England 6½ feet driving wheels are quite as common as 5½ feet with us, and some engines on the Great Western and Great Northern railways have wheels 8 feet or 9 feet in diameter. There is much dispute as to the merits of single *vs.* coupled engines, but I noticed at the last Paris Exposition that all the French express engines shown had their driving wheels coupled. Many of the modern engines have cabs and bogie trucks in front. Distances are given on the Continent in kilometers (0·62 mile each), which have been converted into miles for the sake of comparison here.

In *Switzerland* and *Russia* there are no trains exceeding 27 miles per hour, which are therefore not considered. In Belgium, trains travel as fast as 42 miles per hour, but these are generally through trains between France and Germany, and may therefore be classed with the trains of those countries.

Italy.—The only fast train is the mail, which makes the long run from Bologna to Brindisi, 472 miles, in 14 hours 55 minutes, which, including three stops, is 31·5 miles per hour. This train is largely due to English enterprise. It carries the English mails, and takes only through passengers

France.—Many of the French expresses are fast. I believe the fastest long distance run is on the Orleans line, from Paris to Bordeaux, where 359 miles are run in 9 hours 10 minutes, including 17 stops, an average of over 39 miles per hour. Allowance being made for these, the average running speed is 42·5 miles per hour. I do not think this performance is surpassed in America. From Paris to Marseilles is 536 miles, which used to be covered in 15 hours 25 minutes, at the rate of 34·8 miles per hour, including 13 stops made. The time has since been reduced to 15 hours only.

The expresses on the Northern Railroad run from Calais to Paris, 184½ miles, at 36·7 miles per hour, including seven stops, or at over 39 miles per hour while running. A run of 27 miles is made at the rate of 45·5 miles per hour. I traveled by one of these trains, and found the oscillation of the short carriages tremendous.

On the Eastern Railroad, the schedule time for a run of 47½ miles is 1 hour 5 minutes, and on the Western Railroad I timed the express from Paris to Dieppe, running at its usual rate of speed, 16¼ miles in 20 minutes 20 seconds, or 47·7 miles per hour.

Germany.—Taking Germany and Austro-Hungary together, the fastest trains are found in North Germany. Undoubtedly the fastest train is from Berlin to Hanover, on the Magdeburg-Halberstadt Railroad, 158¾ miles in 3 hours 48 minutes, including three stops=41·7 miles per hour. Deducting these, the speed is 44·2 miles per hour. This beats the fast train from New York to Albany, which is the fastest train in America for that distance. A run of 93½ miles is made by the German train in 2 hours 8 minutes=44 miles per hour. I timed the part from Berlin to Stendal. Some miles were run at 52 miles per hour; 62½ miles were done in 1 hour 30 minutes, including a stop. Berlin to Cologne by this route is 363 miles, accomplished in 9 hours 41 minutes=37·5 miles per hour.

On the Berlin-Potsdam-Magdeburg Railroad, the fast express, I have timed 24¾ miles in 30 minutes=48·7 miles per hour, and 50 miles in 1 hour 9 minutes=43·5 miles per hour. This forms part of the through line between Berlin and Paris, and is, perhaps, the best example of a very long run abroad. The distance is 668 miles, done in about 22¼ hours, or at the rate of about 30 miles per hour, notwithstanding the fact that three countries are traversed with attendant custom house formalities at the frontiers.

Thus it will be seen that the speeds of the fastest Continental trains about equal our own, except in the case noted. For very long runs nothing there equals the speed of the New York-Chicago trains, which average some 35 miles per hour for over 900 miles.

England.—In England, however, we are beaten both in number and speed of fast trains. Mr. Le Van says the average speeds are 20 per cent. greater and the loads 25 per cent. less. Where there are so many rival trains running at nearly the same speeds, it is difficult to name the fastest.

The "Flying Scotchman" (*via* the Great Northern) runs to Edinburgh, 397 miles, in 9½ hours, including stoppages, at nearly 42 miles per hour.

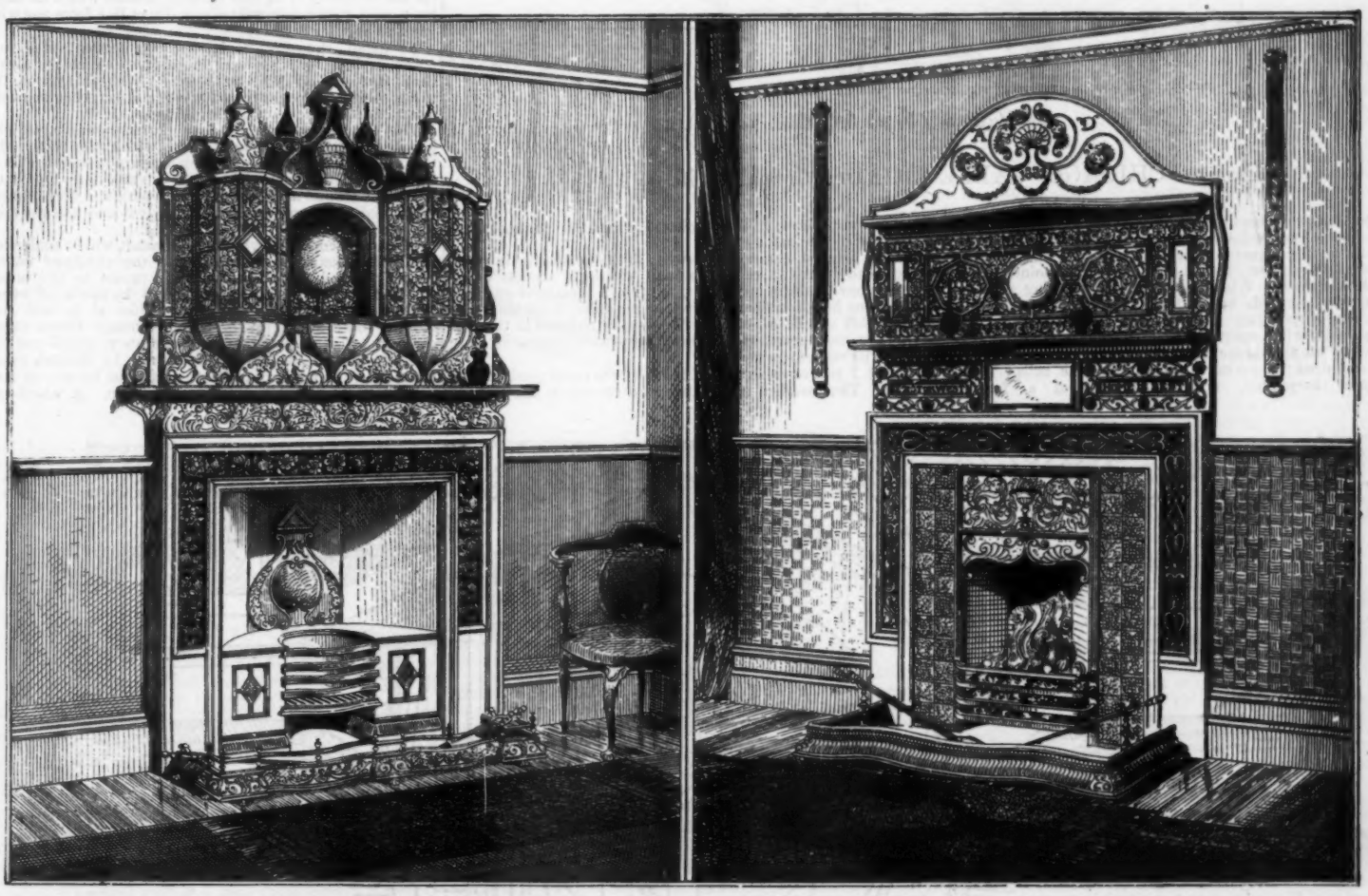
The Great Western has a 7 foot gauge, and formerly its express went from London to Bristol, 118½ miles, in 2 hours =59 miles per hour. This train, known as the "Flying Dutchman," is still, perhaps, the fastest train in the world, though its speed has been much reduced. The 118¼ miles are now made in 2 hours 36 minutes=45·3 miles per hour, including two stops, amounting to 11 minutes. Excluding these, the speed is 49 miles per hour. London to Exeter, 194 miles in 4¼ hours, exclusive of 20 minutes' halt on the way, is 49·5 miles per hour. London to Swindon, without stopping, 77¼ miles in 1 hour 27 minutes, is 53·3 miles per hour.

The Leeds summer expresses on the Great Northern make the 186¼ miles in 3¾ hours=49·4 miles per hour, including two stops amounting to 8 minutes. London to Grantham, 105½ miles, in 2 hours 2 minutes=51·7, and Grantham to Wakefield, 70¼ miles, in 1 hour 17 minutes=54·7 miles per hour. This last is claimed to be the fastest run in the world.

My timing of the Scotch express, the fastest train from London on the Northwestern Railway, may be interesting. Before reaching Rugby, 76½ miles had been traversed in 1 hour 35½ minutes=48 miles per hour. Crewe, 158 miles, was reached in 3 hours 39 minutes (beating the best Continental time for that distance), and Liverpool, 202 miles, in 5 hours, including six stops=55 miles per hour.

A few miles were run in 61 seconds, which is at the rate of 59 miles per hour.

If the speed of American trains continues to improve during the next few years as much as it has recently, we may soon hope to outstrip England, where the maximum has been apparently reached. In fact, Mr. Le Van has prophesied that within five years the distance from Philadelphia to Jersey City will be accomplished in one hour, but this seems rather too much to expect, especially on a road running through such a populous district.



ORNAMENTAL CASTINGS IN IRON.—MANTELPIECES AND GRATES.—DESIGNED BY MAURICE B. ADAMS, ARCHITECT, A.R.I.B.A. EXECUTED BY THE COALBROOKDALE COMPANY.

VANADIUM GREEN.—MM. Osmont and Witz say that vanadic acid, treated with hydrochloric acid, gives a fine green color, which may be employed in dyeing.

CHICAGO CABLE ROADS.*

By D. J. MILLER

THE cable railway system of our city has attracted considerable attention for the past year, not only in Chicago, but in nearly all the cities of the Union, if we may judge from the numerous inquiries made and the number of railway representatives who have visited Chicago for the purpose of obtaining information upon this subject. For a distance of over four miles we have a system of transit which is certainly a great improvement over previous methods of street-car locomotion. I am well aware that I am unable to do justice to a theme of such magnitude, and will only endeavor to give a brief description of some of the principal points connected with the work. With all motors the carrying power is of necessity limited, but with the cable system it is, comparatively speaking, unlimited, and the tractive power of the cable, when operated by a stationary engine, gives this system an advantage over all others, as no dead weight is required to procure adhesion to the rails. It seems almost incredible, but is nevertheless a fact, that when the car is not in motion, the cable passes freely through the jaws of gripper, in which wooden blocks are placed. As these jaws are forced together the blocks are brought in contact with the moving cable, and the friction starts the car with an easy movement, provided the lever is held by a careful operator. Again referring to the drawing, the dotted line, *l*, represents the line of cable when not in grip, the gripper having a clearance of 2¼ inches above carrying pulleys, P. When held in the jaws, the cable is 13 inches below the surface of street, and when on pulleys, P, is 8 inches lower, or 21 inches below the surface of street.

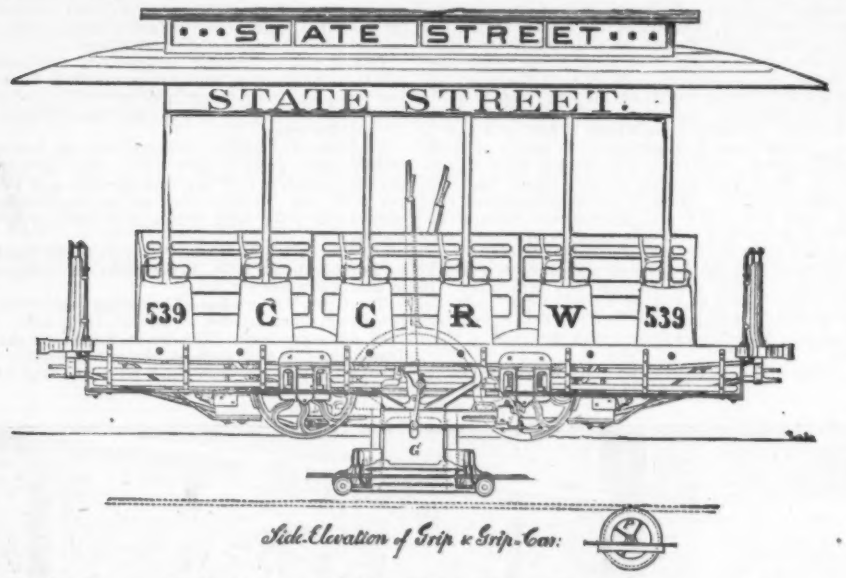


FIG. 1.—CHICAGO CABLE ROADS. (Scale, ¼ in. — 1 ft.)

The greatest expense incurred in this system is in road-bed and tunnel construction, and although several cable roads have already been built, but few of them have cost less than one hundred thousand dollars per mile of double track. Probably this figure will be considerably reduced in time, as the system becomes more generally used and engineers more experienced in the work.

Fig 2 is a cross section of track at curve, as used in this city. The road-bed and tunnel construction is the same as for straight tracks, except that conical pulleys, A, are used on curves, for holding the cable on as direct a line with gripper, G, as may be possible. These conical pulleys are placed 8 feet apart on a radius of from 40 to 60 feet. The angle iron, *a*, is bolted to the slot rail in side of tunnel to assist in holding the gripper in position. There are various designs for road-bed and tunnel construction, no two roads having as yet been built exactly alike, and many designs are suggested by different individuals; some express a preference for a brick tunnel in place of concrete, and others advocate the use of a cast iron tube; but it would be necessary to take into consideration the climate, nature of soil, and grade of streets, before deciding which might be best for any particular locality. In Chicago, the streets are nearly level, and drainage must be secured for tunnel; consequently a greater depth is needed than where streets are not of uniform grade. The tunnels here are from 3 feet and 4 inches deep at the summit to 3 feet and 7 inches at catch basins; and this, with grade of street, gives a fall of 3½ inches in 100 feet. The catch basins are located every 360 feet, and connected with city sewers by overflow pipes. There is no objection to a deep tunnel, and, as in some of our severe winters it will be important to dispose of the water which may accumulate in the tunnel, if drainage be insufficient, trouble may be expected.

Wabash and Cottage Grove avenues will be in operation about the last of November of the present year. These lines are operated from the building at corner of State and Twenty-first streets, and the cables receive motive power from the machinery running State street lines. Cables for operating these avenues must be carried some distance from the building before they are brought into actual service. Cottage Grove avenue line commences at the intersection of Cottage Grove avenue and Twenty-second street, about 1,920 feet from the operating room. This line runs south 11,642 feet to wheel vault south of Thirty-ninth street, and then returns, making the total length of cable 27,124 feet. Wabash avenue cable is brought into use at the intersection of Wabash avenue and Twenty-second street, and will run north on Wabash avenue to the center of the block between Monroe and Madison streets, and then return, and the length of this cable will be 22,873 feet.

These cables are carried from the operating room to their respective lines through a third tunnel between the railway tracks, and where angles are made excavations are provided for the reception of 12-foot sheaves, around which the cables are passed, thus holding them in a direct line from one wheel vault to another.

To avoid shunting devices in connection with cable trains, a belt line has been adopted, on which State street cars pass east on Madison street to Wabash avenue, then north to Lake street and west to State street, then returning south making a circuit of three blocks.

This belt line is operated by an auxiliary cable, which is propelled by the end wheel, upon which the State street main cable reverses. This transmission of power is effected by carrying the main cable into a vault (see Fig. 3) and passing it around a 12-foot sheave to which a 6-foot sheave is coupled for operating the auxiliary cable at half the speed of main cable.

The arrangement of wheels in the vault will be understood from the illustration given. After the auxiliary cable is carried around the 6-foot sheave, it passes to the tension wheel, T, which keeps the cable taut by means of weight, W; cars moving north exchange cables at B, and those moving south at E. Wabash and Cottage Grove avenue cars are to be operated around the above-mentioned belt line by a similar auxiliary cable (driven by Wabash avenue main cable) and return to Wabash avenue by way of Madison street, then south on the return trip. A wheel vault

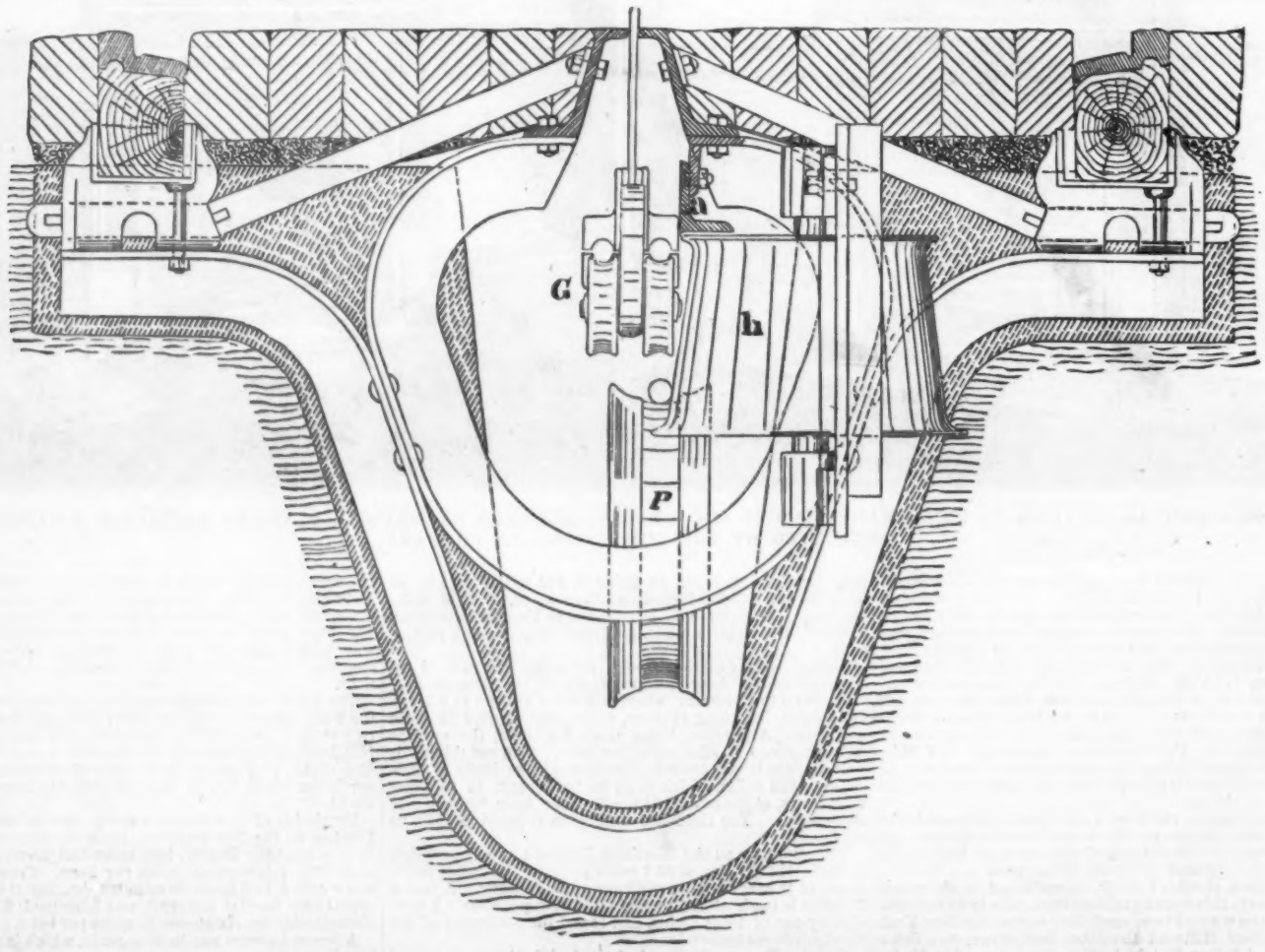


FIG. 2.—CHICAGO CABLE ROADS.—SECTION OF TRACK AT CURVE. (Scale, $1\frac{7}{16}$ in. — 1 ft.)

similar to the one on State street is located on Wabash avenue for transmission of power to the auxiliary cable, consequently two cables will pass around the belt line in the same tunnel, each operating its own line of cars.

It will be seen that two cables in one tunnel will be taken around the curves at corner of Lake and State streets, also corner of Lake street and Wabash avenue. Although an arrangement has been designed for this purpose, as it has not yet been tried I deem it best to omit a description.

Railway officials are generally interested, and seem anx-

the State street road, now in operation, has a carrying capacity of ten thousand passengers per hour, and even this enormous traffic will not overburden the cable.

Fig. 1 is a drawing of grip and grip-car used by the Chicago City Railroad Company, and the position of the cable in the gripper, G, will be readily understood by reference to the same (I wish to give Mr. Oscar Lundquist credit for making this drawing for me).

* Read before the Western Society of Engineers, October, 1882.

ious to ascertain the percentage to be saved by the use of the cable system.

Much depends on the manner in which a road is built, for if constant repairs must be made and the same number of horses maintained as if using animal power, it would be a difficult matter to find wherein a saving were effected; but if a road be properly constructed, there is every reason to suppose that a gain of from 30 to 50 per cent. would be made where from 200 to 300 horses were needed for the work, and from 60 to 70 per cent. could probably be realized on larger roads with heavier traffic by careful and judicious management.

I think the use of duplicate cables would materially assist in the perfection of this system, as in case of accident to one cable there need be no stoppage of the road. The use of a single cable necessitates having horses in readiness for an emergency, and a cable road is supposed to dispense with the use of animal power. If employing two cables, it is evident that no horses need be retained, for if one cable be disabled the other could be called into immediate use, or both might be used simultaneously. A road can as well be built for using duplicate cables as for a single one, and the difference in cost of construction would be nothing compared to the benefit derived.

State street is now operated with two single cables, one running north and the other south from the engine house at Twenty-first street.

The indicated horse-power of the engines, divided by speed of cables, gives the strain on all the cables as 5⅛ tons, and if to this is added one-half of tension weight, we have 6⅛ tons load for the two State street cables.

If but one cable was used to do the work, it would require a rope eight miles long, and I should not consider this length objectionable, provided the cable was not overloaded, and, as in this case, the strain is but 6⅛ tons, and the proper working load of a steel cable of this size (1¼ inches in diameter) is 8 tons, I can see no reason why one cable would not be sufficient. The breaking strain of a steel cable 1¼ inches in diameter is 39 tons.

Objection has been made to the use of long cables on account of the sway or variation of speed; but if engines were well governed, I do not believe this would be sufficiently marked to be objectionable, and all moving cars would assist in keeping the cable at uniform speed. By doubling the length of the ropes and increasing the number of sheaves, State street could be operated with duplicate cables.

The cable system is not of recent origin, as might be supposed. We find by examining the United States Patent Office records that the first patent of importance was granted on improvements in tracks for a city railway to G. S. Gardner, of Philadelphia, in 1858, and as it may be of interest, I will give his claim in full, without the Patent Office drawing. The inventor says:

"I claim forming between the rails of a city railroad track, an underground tunnel, and hanging a series of pulleys within the same, said tunnel having a longitudinal slot near the level of the ground, and being otherwise so arranged that a rope may be used for drawing the cars along the track without impeding the passage of vehicles across the same."

There have been over 130 patents granted by the United States Patent Office on cable traction, but I have no knowledge of a patent which covers the system, and a cable road can be built without infringement, although it might not be advisable to ignore all patented improvements.

The numerous fatal accidents resulting from the introduction of this system are to be deplored, but from present indications we believe there will be no recurrence of these misfortunes, as people are becoming accustomed to the cable, and operators more skilled in its management.

No doubt, radical changes will be made in the system, and we may, in the near future, see cable cars operated with comparative safety in our cities at a speed of 10 miles per hour, which is certainly to be desired.

The conversion of these roads from animal traction to the cable system was certainly a gigantic undertaking, and required more fortitude on the part of the projectors of the scheme than may be supposed, as there were many obstacles to be overcome, and considerable outlay to be made in experiments, these roads differing in many respects from those previously constructed; but the originators of the project have reason for congratulation, and should receive the gratitude of the public in general for so successfully supplying means of comfortable and easy transit.

[The cable roads of Chicago are modeled after those that were put into use several years ago in San Francisco. A full account of the latter with thirteen illustrations will be found in SCIENTIFIC AMERICAN SUPPLEMENT, No. 298.]

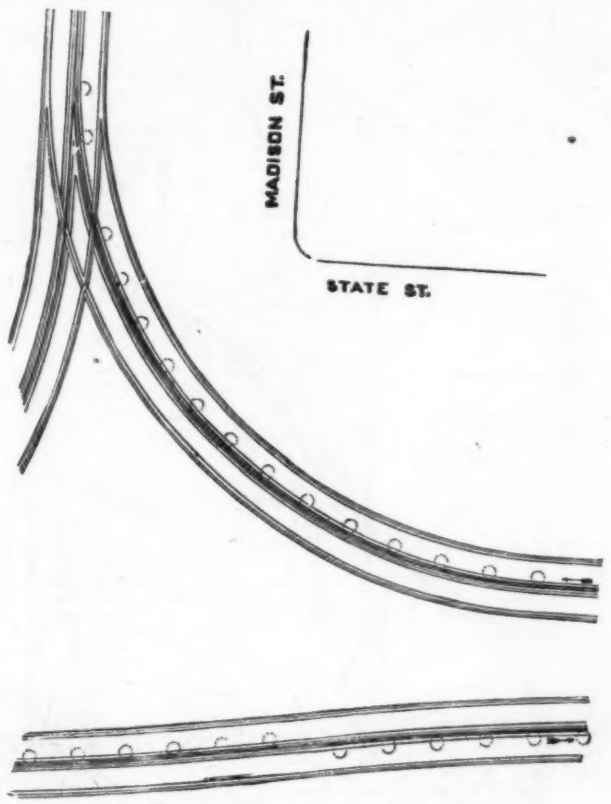


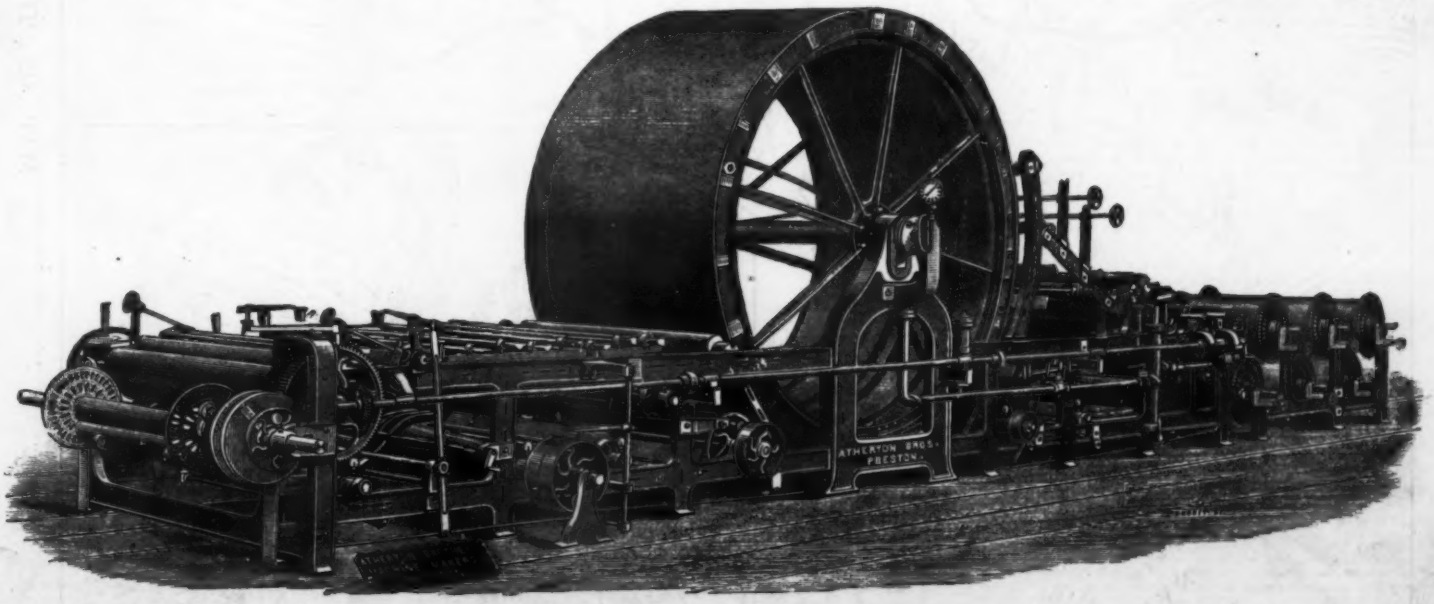
FIG. 3.—CHICAGO CABLE ROADS.—PLAN OF CURVES AND CROSSING

IMPROVED SIZING MACHINE.

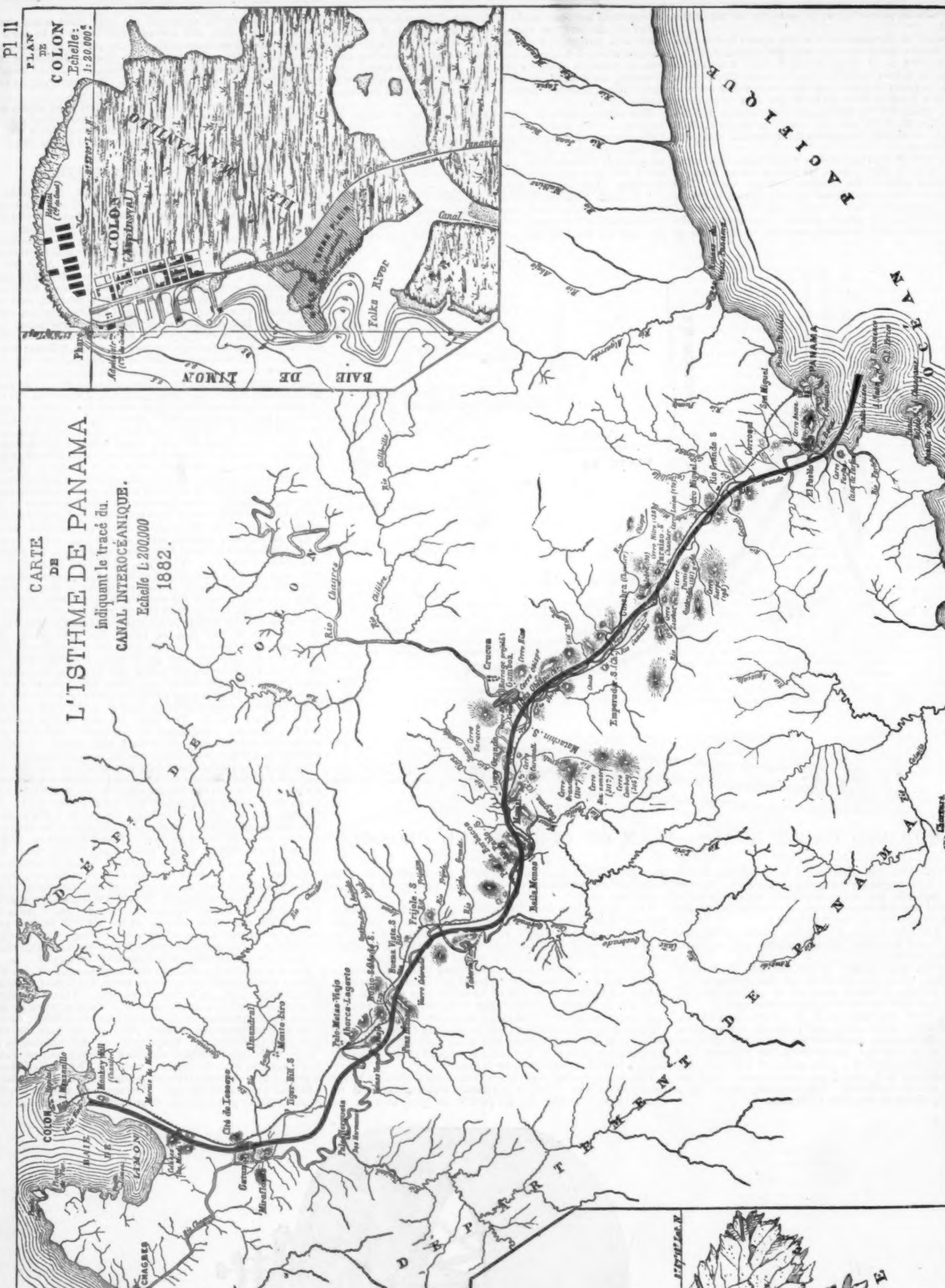
THIS machine, by Messrs. Atherton Bros., machinists, of Preston, follows the general construction of the "slasher" type. The makers claim sundry improvements in the different parts, not so much in arrangement as in details.

The duty done by the sizing machine is twofold—it not only, as its name implies, sizes the yarn, but it also produces the weaver's beam from the warper's beams. As a test of the efficiency of the machine, the sized warp should be compactly wound on the weaver's beam, and delivered for winding thereon in a cool, dry, and mellow condition, and not asky—yarn which is rough and hard because the size upon it has been baked. The achievement of these points has been the object in view of the makers of the machine. The course of the yarn through the machine is as follows: Leaving the creel it travels over the carrying rollers into the sow (size) box, thence under a copper immersion roller, which keeps it immersed in the size; it then passes between two pairs of squeezing rollers, the bottom ones of copper and the top of cast iron, and made heavy to obtain the desired weight for expelling superfluous size. Referring to the right-hand of the engraving, the warp now strikes the direction toward the top of the drying cylinder, round which it is carried in contact with about seven-eighths of the circumference, when it passes off and is taken in a circuitous direction round a series of carrying rollers placed between size box and cylinder. The circuitous route of the yarn at this part enables several fans (four actually) to be arranged to send a draught of air into both sides of the warp. Leaving this part, it passes underneath the cylinder to the beaming end of the machine, where it also passes over another series of carrying rollers so disposed as to admit of three fans being arranged to blow upon both sides of the yarn. The warp, after being divided or the ends separated by a number of splitting rods, passes between a pair of nipping rollers, thence on to the weaver's beam. Such in general terms is the working of this class of machine. The yarn in the first instance is drawn off the beams in creel by the squeezing rollers in the size box, and afterward over the cylinders by the nipping rollers last mentioned. All these rollers are geared together and are proportioned relatively to each other to give the smallest possible tension on the ends. To obtain the last practicable strain is, of course, a matter of much importance, and from this point of view it is argued that large drying cylinders are to be preferred, because from the longer leverage they give the yarn they are easier to pull round. The large cylinder of this machine is 9 feet diameter, constructed on the cavity principle, and we understand that they are at work with warps of from 500 ends up to 4,000, some examples being with very fine counts. They possess a further important advantage in the fact that they give a large drying surface, and therefore for the same speed of production the yarn remains longer in contact with them, and a lower temperature will suffice for the work. As, for example, at Messrs. Hawkins' mill, with 3,200 ends of 32's, the large cylinder machines work with 5 lb. steam as against 10 lb. in small double cylinder machines, with a marked improvement in the mellowness of the warp, but with lighter work from 2 lb. to 2½ lb. steam is sometimes sufficient. That is to say, the risk of baking the yarn, hardening it, and making it asky, is reduced, and the quality of the cloth is, as a result, improved. The weavers also, we were informed, show a decided preference for the warps from the large machines. The softness of the warp is further promoted by the use of fans, which act as drying agents as much as cooling. The makers of the machine under notice claim to have a larger number than commonly employed.

Other points in the machine that may be noticed are: The presser arrangement for the warp beam, the object of which is to obtain a compact laying of the yarn. This, we believe, is accomplished in a novel manner. There are two presser levers, each operating on its own half length of beam, so that both ends of beam are pressed, although the yarn on one-half may be irregular. The driving of the machine is on the positive drag principle, regulated by strap cones working in connection with the nipping rollers. The weaver's beam is driven by a separate friction motion regulated by a hand-wheel screwed upon springs. The marking motion applied is on the faller principle, the construction of which has been



IMPROVED SIZING MACHINE.



MAP OF THE ISTHMUS OF PANAMA, SHOWING THE LINE OF THE GREAT CANAL.

improved with the object of obtaining greater accuracy in the marking. On one side it marks the "cut" lengths, and on the other the "scarf" lengths, or subdivisions of the "cut."

The construction of the cylinder, which is 66 inches wide on face, and, as we have said, 9 feet diameter, has also received much attention. The outside case or the surface is made of stout sheet copper, the inside of stout tinned sheet iron; the buckets inside are copper, with copper steam and water tubes, connected to the cylinder by brass unions so as to be readily detached if required for repair. These pipes are provided with a neat and simple expedient (by which leaky joints are effectually guarded against), to allow for expansion and contraction. The size box is copper lined, and contains an extra boiling compartment to insure good boiling. The brush motion consists of one large cylinder brush running in brass bearings, with a clearer brush attached. The creel may be arranged for any even number of beams from 6 to 14. The average production, we are informed by the size, with one of the machines we have described, is about 2,860 cuts of 40 yards per week with 30's yarn. At the time of our visit the speed was about 40 yards per minute.—*Textile Manufacturer.*

THE PANAMA CANAL.

WE give opposite a map of Panama, showing the exact line of the great canal and the other remarkable works that it involves. The realization of the enterprise has now fairly begun, and the work is being executed with great vigor. For a full description of this map, see SUPPLEMENT, No. 329.

THE MOVING OF LARGE MASSES.

I HAVE often heard people, even engineers, ask with astonishment how it was possible in ancient times to raise the large stones of Carnac, or the obelisks, construct the pyramids, move siege towers, and accomplish a host of other operations which appear to us to be out of proportion to the limited means that we attribute to the civilizations which have preceded our own.

FIG. 1.—GIN, WITH PULLEYS AND WINDLASS.

In the first place, it is not correct to say that the ancients were inferior to us as regards machines designed for maneuvers of force. It is certain that they did not apply their genius in substituting tools for the human hand in industrial works, since, thanks to slavery, they had no need to do so; but, when we take the trouble to study the history of labor, instead of devoting ourselves to that of wars, we find that they have anticipated us in the majority of such inventions as are qualified to increase the power of man. The windlass and pulley may be traced back with certainty to Archytas of Tarento, a contemporary of Plato, and the screw to Archimedes. It is extremely probable that all these machines antedated the mathematicians to whom is attributed their invention, because of their having been described for the first time in the works of these authors. This is not the place to enter upon an archæological dissertation on the subject. I propose simply in this article to show that it is by the aid of the simplest machines that it has been possible in our day to move the largest masses, and for the reason that the heavier the weight the less it is necessary to lose in friction.

REMOVAL OF THE PEDESTAL FOR THE STATUE OF PETER THE GREAT TO ST. PETERSBURG.

The largest mass that has ever been transported is, I believe, the rock from which was cut the pedestal for the statue of Peter the Great at St. Petersburg. This rock was a block of granite weighing about three million pounds, or about fifteen hundred tons, and was found isolated in a swampy soil at 6 kilometers from the Neva. It had the form of an irregular prism, 7 meters in height by 14 in length and 9 in width at its largest dimensions.

An Italian nobleman, Count Marin Carburi, a lieutenant-colonel in the Russian service, offered to bring it to the spot where the statue of the Czar was to be erected.

The first operation consisted in disengaging it from the ground, in which it was buried to a depth of 5 meters. To do this, an excavation was made all around it to the above depth, and to a width of 28 meters. Then a slope was made (1 to 40) 12 meters wide by 200 long, so as to carry it up to the level of the surrounding plain.

Turning the rock over.—In order to bring the rock into the position proper for the use to which it was destined, it became necessary to give it a quarter turn. This was done as follows:

Gins were constructed of fir poles starting from a triangular base formed of pieces of wood squaring 7 inches. These pieces of wood were united at their angles by iron, and each angle contained a mortise for the reception of the uprights of the gin. These uprights squared but 5 inches,

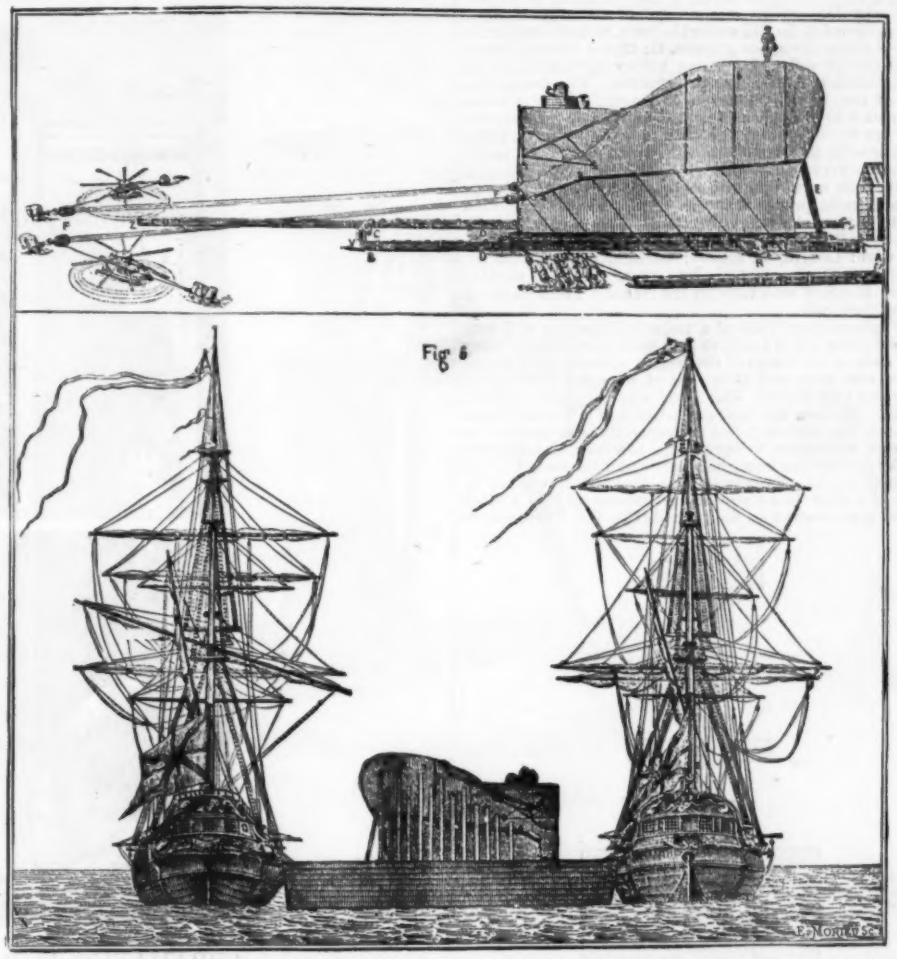


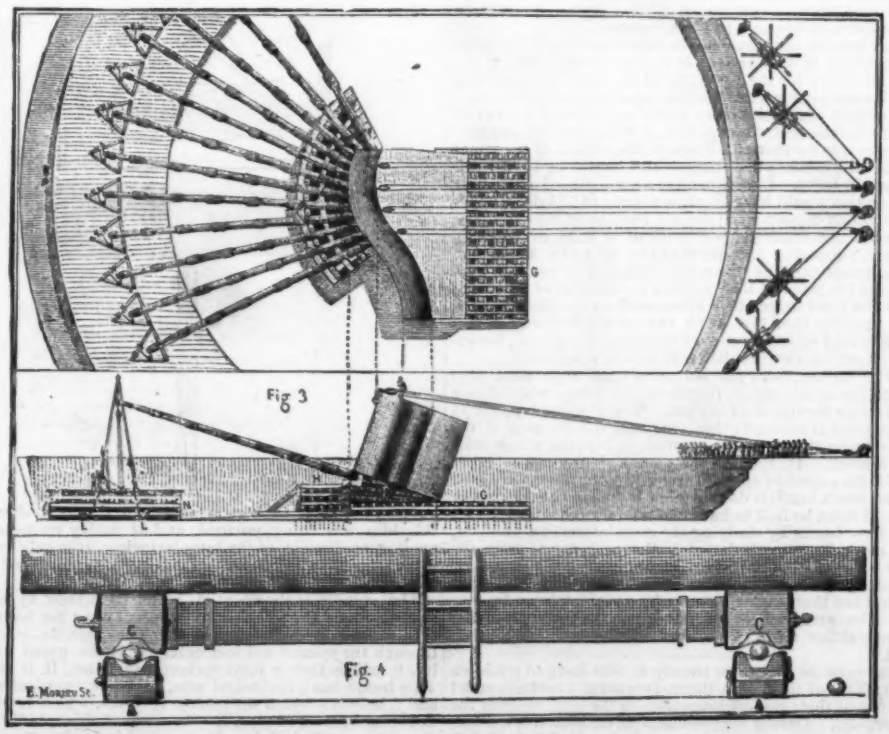
FIG. 5.—MOVING OF THE ROCK OVERLAND. FIG. 6.—CARRIAGE OF THE ROCK BY SEA.

and were united at the apex by iron hoops (Fig. 1). In each gin there was a fourth upright, shorter than the others, which connected one of the sides of the base with one of the uprights and served to support a windlass. Each gin had also two pulleys—one at the top, and the other at the side of the base—so that, according as either of these was paired, by means of ropes, with a third pulley attached to the end of the levers, the latter could be raised or lowered. Each lever was formed of three masts tapering to one end, and lashed together with ropes. The large end of these was 0·30 to 0·35 of a meter in diameter, and their length was 22 meters. Twelve of these were arranged side by side, as shown in Fig. 3. It took but three men to turn each windlass, and these three were also sufficient to move the gin by means of iron levers whenever it became necessary to do so.

Before beginning operations, there was erected on piles, at the side, G, on which the rock was to be turned, a platform consisting of four rows of horizontal joists crossing each other alternately, and surmounted by a layer about two meters thick of mixed moss and hay to deaden the fall. Piles were likewise driven on the side, H, to serve as fulcra for the levers. To aid the action of the latter, there were placed on the opposite side four capstans, which were connected by means of ropes two inches in diameter with four iron rings sealed into the rock with lead. Each capstan was provided with eight bars, and put in motion by thirty-two men. Orders were transmitted from Count Carburi, and time beaten for the laborers by means of two drums placed on the rock.

Each operation of the levers raised the rock 30 to 40 centimeters. All the capstans were then fixed, and the men who manned them went and placed beams and wedges under the rock, so as to hold it while the levers were being taken out and a new operation was being prepared for by raising the fulcra, H, and the scaffolding, N, that supported the gins. When the rock had been brought nearly to a point of equilibrium on its lower edge, its fall was retarded by holding it back by means of six other capstans that were then placed at the side of the levers.

Moving the rock overland.—Count Carburi at first thought of employing rollers, but gave up the idea, because (1) the friction would have been so great that traction could not have been effected;* (2) the rollers would have had to be



FIGS. 2 & 3.—ARRANGEMENT OF THE LEVERS AND CAPSTANS. FIG. 4.—DETAILS OF THE GROOVES.

* Rondelet has established the fact by experiment that, to move a block of stone weighing 1,000 kilogrammes, it requires:

A stress of	750 kilos.	in drawing it over an uneven ground;
"	650 "	in drawing it over a wooden flooring;
"	600 "	in drawing it on a wooden platform sliding on wooden floor;
"	180 "	on soaping the contact surfaces of the platform and floor;
"	35 "	on placing the stone on rollers 0·07 m. diameter resting on the ground;
"	25 "	on placing the rollers between the stone and a flooring;
"	22 "	on placing the rollers between a floor and a platform supporting the stone.

In other words, the force necessary to move a stone over an uneven surface is equal to two-thirds of its weight, and is reduced to three-fifths of the weight by sliding on a flooring; to five-ninths by the sliding of wood on wood; to one-sixth when the woods are soaped; to one-thirty-second when rollers are placed between the stone and ground; to one-forty second when the rollers run over a flooring; and to one-fiftieth when they revolve between two surfaces of wood.

of bronze, so as not to be crushed, and the construction of such presented difficulties; (3) the rollers would not have been able to remain parallel during progression, because of the unequal distribution of the weight of the rock; and if an attempt had been made to keep up the parallelism by placing them in properly hollowed out cross-beams, the friction would have been notably increased, and the beams would have been broken.

The Count therefore decided to substitute for rollers spheres movable in grooves. Proceeding according to the theoretical idea that friction diminishes with the extent of the surfaces in contact,* he gave the grooves the form shown in Fig. 4.

The carrying apparatus consisted of three parts: (1) a frame designed to be slid under the rock, so as to support it, and containing the upper grooves, C; (2) the lower grooves, A, laid on the soil and forming hollow rails; and (3) the spheres running between the two grooves. The frame consisted of two beams, 14 meters in length, 0·30 of a meter wide and 0·45 of a meter thick, connected by cross-pieces of thinner wood, so that the rock should not rest on them, and by iron tie-bars bolted at their extremities. The metallic grooves were set into the two beams.

As the rails were designed to be replaced in measure as the rock made progress, and as they consequently did not have to support its weight constantly, they were not quite so strong as the beams composing the frame. Their dimensions were: Length, 11 meters; breadth, 0·38 of a meter; thickness, 0·33 of a meter. Into them were set metallic grooves identical with those in the frame. There were ten pairs of these rails.

The spheres were 0·135 of a meter in diameter, and were arranged about a foot apart, so that there were always thirty under each of the beams of the frame. Carburi tried at first balls of cast iron, and afterward of wrought iron; but in both cases they broke. The same was the case with the grooves. He then had both constructed of a bronze formed of copper, tin, and zinc, and consequently analogous to the alloy that we employ to-day for the bearings of machines. In order to slide the frame and rails under the rock, Carburi had iron screws constructed that could be revolved, by means of a lever, in a stationary bronze-nut set into a block of hard wood resting on the ground (Fig. 7). These screws

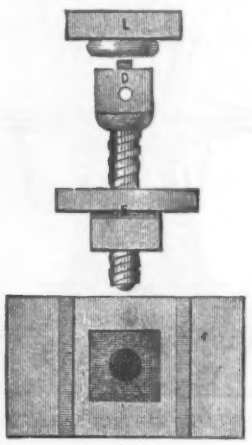


FIG. 7.—JACK-SCREW.

were only 0·20 of a meter in diameter, and their force was such that twelve of them sufficed to raise the rock.

In order that the rock should not sink into the swampy ground over which it was necessary to transport it, the work was postponed until winter, when the ground should be frozen; and wherever it was found necessary, the road was consolidated with gravel, piles, and trees.

Traction was effected by sinking along the route, at every 100 meters, very large stakes, to which were affixed the ropes that held the necessary pulley blocks and capstans. The hauling ropes ran around the rock longitudinally. The spheres were kept apart by men seated on mats attached to the sides of the frame. When the end of the rails was reached, the set that had been passed over was taken up and carried forward to be laid in front (Fig. 5).

Everywhere where the ground was level, two capstans, each actuated by thirty-two men, were found sufficient; and with these the rock was moved forward one kilometer per week, and, consequently, about 150 meters per day of five hours (winter).

Several times it became necessary to change the rock's direction. To do this, there were placed under it, after jacking it up, turn-tables revolving on spheres, whose arrangement may be readily imagined.

It was also necessary to ship the rock to carry it part of the way by water. Figure 6 shows it floating on a flat-boat towed by two ships. The props seen at the sides were designed to distribute the weight over the whole surface of the boat and prevent the latter from getting out of shape through pressure of the water.

I shall not enter into the details of the shipping and unshipping, as an account of this may be consulted in the narrative published by Carburi in Paris in 1777. What I have said is sufficient to show the powerful effects that may be obtained by very simple arrangements.—*A. De Rochas, in La Nature.*

APPARATUS FOR DESCENDING INTO MINES.

MR. HATON DE LA GOUPILLIERE, Engineer in Chief of Mines, has just published in the *Annales des Mines* a description of an extremely simple and convenient apparatus to permit of descent into mines of small depth, say from 120 to 160 feet. The idea is an Australian one.

The mechanical system consists essentially of a windlass (which in the accompanying figures is seen over the mouth of the pit), of a rope, and of a bag filled with sand.

We shall first describe the method by which a person can ascend or descend without aid from another.

The ordinary rope of the windlass makes two revolutions on the drum, and has at each extremity a hook, as shown in Fig 1. The miner passes this hook over a knot at 36 inches distance from the extremity, and makes a loop into which he seats himself, or through which he passes one leg only. At the other end of the rope there is attached a bag of sand weighing about 120 pounds, that the miner lets down ahead of him. In order to form an endless rope, there is a second one, which we shall call the steadying rope, and which is hooked to the extremities of the first in order that the difference of the two weights (that of the man and the sand bag) shall remain constant at every moment of the descent. The miner seizes both ropes, the descending one to keep himself in equilibrium, and the ascending to govern his speed. He at first descends slowly until the sand bag leaves the bottom, and then begins to move quicker, holding all the time the ascending rope between his legs. When he has nearly reached the bottom, he again seizes this rope with his hand and gradually slackens his motion until he stops it entirely as he reaches the end of his journey. He then fastens the rope by the end on which he was seated, so as to keep the sand bag suspended above.

When he wishes to ascend, he seats himself as before, and pulls on the steadying rope, which at its upper part is attached to the counterpoise. Then, by continuous pulls, he easily raises himself with a speed of 80 inches per second. Although the resistance is constant and the man's pulling is intermittent, the impulsions that he gives are repeated sufficiently to keep up a continuous motion in the quite large mass of the movable part of the apparatus.

Before leaving the particular case just described, we must make a couple of observations as to the exact measure of the power necessary for the ascending of the miner. In the first place, it must be remarked that the rope being an endless one, the ascending and descending parts are at every instant of the same length, and, consequently, it will produce no change in the stress to be exerted. Suppose the weight of the miner to be 62 kilogrammes and that of the bag to be 50, the difference will be 12. Consequently, a man placed externally to the system would have to exert a stress of 12 kilogrammes and a fraction dependent upon the friction of the windlass; and would accomplish a total work of 12 × 50, or 600 kilogrammes, supposing the depth of the pit to be 50 meters. But the miner exerting the stress rises just so much in proportion as the point of the rope that he has hold of descends; so that the hand descends twice as much as the man ascends.

The result is that the stress exerted by the hand is half what it would be for a person external to the system, for example, a person turning the crank of the windlass.

In the ascent from the bottom all the rope must pass through the miner's hand, that is to say, a rope which has a length twice the depth of the pit. Now the total power to be expended is evidently just the same for the man at the windlass who draws up his comrade as for the miner who raises himself. If, then, in the case of the man who raises himself, the extent of space traversed by the stress (that is to say, the man's hand) is double what it was in the other case, the stress must be half to have the product the same.

We have begun by studying the most interesting problem; but it must be remarked that in the majority of cases the man who is to descend is not alone, but accompanied by comrades. Now, when there are several to aid each other, we shall see that each one may be easily let down by two men. The arrangement of the apparatus in such a case does not differ much from that of the first, as seen in Fig. 2.

Let us suppose that some twenty miners have to go down the pit: Two of them place themselves at the windlass and let down one of their companions seated in the loop, without the counterpoise. During the passage from the mouth to the bottom of the pit, the man who is being lowered holds in his left hand the rope that supports him, and allows his right hand to slide over the safety-rope, to which he will hook himself in case of danger. This latter rope, which we just called the steadying one, has no longer in this case the same function. It is attached to the base of the windlass and runs along the side of the pit from top to bottom, and the reader will easily see how it merits its new name of "safety-rope."

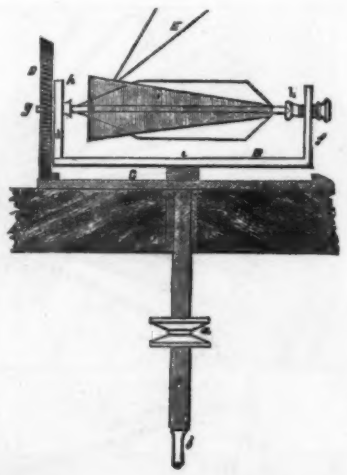
When the men at the windlass have lowered the last of their comrades, the latter hooks to the end of the rope a bag of ore weighing about 65 pounds. The first of the windlassmen then descends, as shown in Fig. 2. The bag of ore serves him as a counterpoise; and as he holds the safety-rope in his hand, the labor of his comrade is much facili-

APPARATUS FOR DESCENT INTO MINES.

tated. On reaching the bottom, he hooks the safety-rope to the extremity of the windlass-rope and fastens on the 120 pound bag of sand of which we have spoken. The last windlassman then detaches the rope from the base of the windlass, hooks it on the windlass rope so as to make it endless, and descends as we have explained in the beginning.—*La Nature.*

A DOUBLING ARRANGEMENT FOR FLAX.

THE idea of doubling yarn by the rotation of the bobbin in the plane of its axis has been so often attempted that it is almost a worn-out subject, the obstacles to its useful application having generally been insuperable. Some time ago we



gave an acount of such an arrangement simply to show that this idea was being pursued, and if to-day we reproduce another application of the same principle, it is only because it has been patented by a French flax spinner of some standing.

The spindle is shown at A, which is driven by a band passing round the wharf, *a*, in the usual way; the bolster for this spindle is at the top at *c*[1]. This spindle is carried through the spindle rail and enlarged at the upper extremity, to which then a light rectangular frame, B, is riveted. This frame has a horizontal arm, *e*, and two vertical ones, *d* and *f*, between which the spindle revolves, which carries the doubling bobbin, or pirn, K. One end of this spindle passes through a vertical pinion, D, at *g*, and is fixed to this pinion so that it must turn with the latter, while the other end of

* It is generally admitted at present, from the experiments of Amontons and Morin, that friction is independent of these surfaces in contact, and that it varies only with the nature of such surfaces and with the pressure. This law is explained by saying, the greater is the number of points in contact, the less is the pressure at each point. Carburi's experiments with rollers seem to confirm the contrary opinion sustained by Coulomb. All the builders of machines whom I have consulted assert that friction notably increases with the surfaces in contact for strong pressures.

PUBLIC LIBRARY OF THE

the spindle has its seating in a small bush which is pressed to it by a spiral spring. The pinion, D, runs upon and gears into a horizontal wheel, C, attached to the spindle rail. The yarn to be doubled is guided upon the bobbin by a traverse motion indicated at F. It will thus be seen that by rotating the spindle, A, the frame, B, revolves, and in doing so turns the pinion, D, and through it the bobbin, K. The motions seem simple, but we still question its usefulness, for the necessity of revolving the bobbin in a horizontal direction must needs consume a great deal of power, nor do we see how it is possible to alter the twist without the speed of the spindle.—*Textile Manufacturer.*

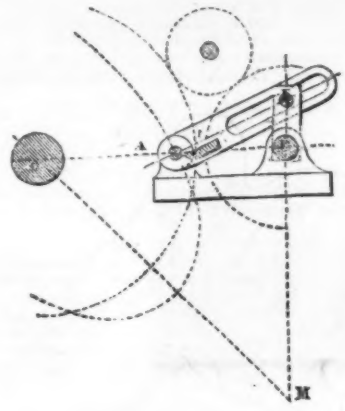
NEW METHOD OF GUIDING THE TOOL IN AN OVAL LATHE.

IN an oval lathe the tool is perpendicular to the surface that it is turning only at the extremities of the axes of the ellipse. At every other point it makes with such surface a variable angle, and this obliquity tends to make the cutting edge of the tool either recede or enter too deeply, according as it makes an obtuse or acute angle with the tangent to the ellipse.

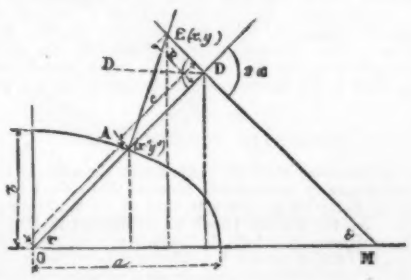
We can, by applying the following property of the ellipse, force the axis of the tool to remain always perpendicular to the ellipse that it is turning. The property mentioned is as follows :

If we prolong a sector radius, O A, of an ellipse by a constant quantity, A D=c, and if we carry through the point D a straight line which makes an angle, D M O=D O M=ω, with the longer axis of the ellipse, the length, D E, determined by the intersection of the right line, M D, prolonged with the perpendicular, A E, of the ellipse to the point, A, will be constant, and reciprocally.

To apply this theorem, it will suffice to cause the cutting edge of the tool, t, to pivot around an axis, A, that projects upon the ellipse to be traced, and to actuate such pivoting by means of a slotted rod moved by a winch, D E, which revolves with twice the velocity that the axis, ω, of the lathe does, and in the same direction.



When the longer axis of the ellipse coincides with the straight line, O A D, the winch, E D, must likewise coincide with this direction, the point, E, being between O and D. As the winch, E D, revolves twice as fast as the axis, O, the angle, O D E, will always be twice greater than the angle, D O M. This is a realization of the reciprocal of the theorem enunciated above, in which we have A D=c, and D E=R. The cutting edge of the tool, then, will always remain perpendicular to the ellipse.



Such a mechanism will serve for turning ellipses with axes 2 a and 2 b, on giving the length of the winch, D E, the value :

$$D\,E=R=\frac{a^2-b^2}{a^2+b^2}.$$

Let, in fact :

a, b, be the semi-axes of the ellipse;
x, y } the coordinates of the points { E;
x', y' } { A;
c, the constant length A D;
r, the vector radius O A;
ω, the angle D O M=D M O=E D D';
R, the length E D;

And we shall have :

$$x=(r+c-R)\cos\omega;$$
$$y=(r+c+R)\sin\omega \qquad (1);$$
$$x'=r\cos\omega \qquad (2);$$
$$y'=r\sin\omega,$$
$$\text{and } (y-y')\,b^2x''=(x-x')\,a^2y' \qquad (3).$$

Substituting the values of x, y, x', y', drawn from 1 and 2 in equation 3, which expresses that the point x y is on the perpendicular to the ellipse at x'' y'', we shall have for R the expression :

$$R=\frac{a^2-b^2}{a^2+b^2}c.$$

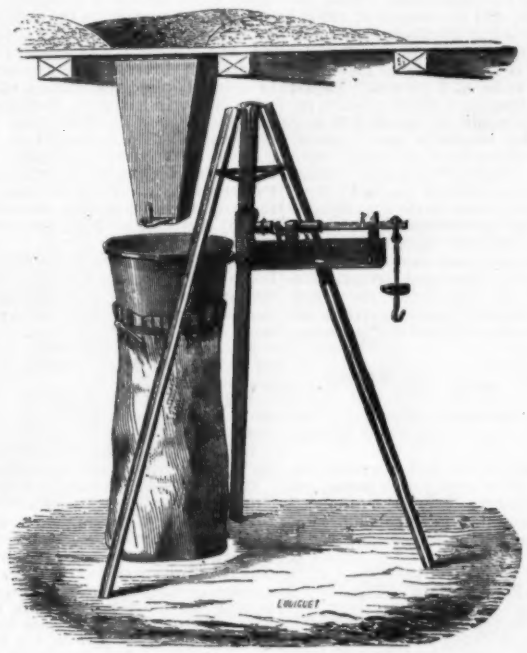
It will be seen, besides, that we always have:

Angle O D E=2 D O M=2 ω.

—*Revue Industrielle.*

PAUPIER'S BAGGING SCALES.

IN many industries, successive improvements introduced into the apparatus employed therein finally considerably reduce manual labor and do away with manipulations that are always costly. The apparatus shown in the accompanying figure presents many advantages from such a point of view, because it permits of bagging and weighing, at a single operation, all sorts of materials, such as grain, flour, seeds, sugar, etc. These portable scales consist of a wooden tripod, whose apex is connected by hooks with a Roman balance. The small arm of the latter is connected by means of a stirrup-shaped iron with a sheet iron funnel from which is suspended the empty bag; the latter being held in place by a grip collar resting on an annular flange. After placing the funnel under the hopper connected with an upper story of the



PAUPIER'S BAGGING SCALES.

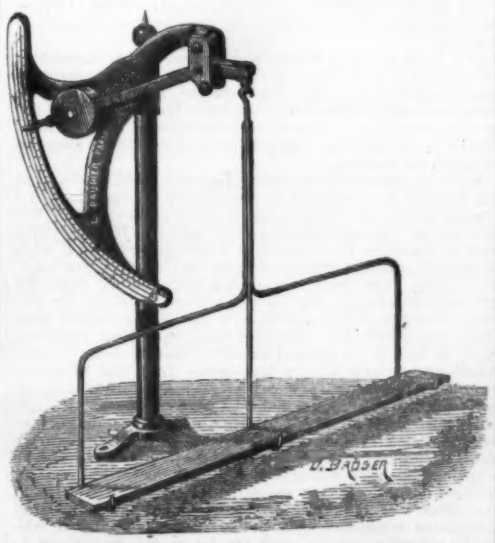
building, and regulating the slide of the balance according to the quantity of material to be admitted into the bag, the slide of the hopper is drawn back and the bag is allowed to fill until the slide indicates an equilibrium. A small pan, suspended from the extremity of the long lever, receives, before operations, the weight necessary for the tare.

The apparatus is furnished by its manufacturer in six different sizes, capable of weighing from 200 to 1,000 kilogrammes.—*Revue Industrielle.*

MACHINE FOR WEIGHING AND CLASSIFYING ZINCS.

THE apparatus shown in the accompanying cut, although it may be employed for different purposes, is specially designed by its inventor for weighing and classifying sheets of laminated zinc.

It consists of an iron standard upon which is mounted, by means of a socket, a cast-iron, graduated, quarter-circle sec-



MACHINE FOR WEIGHING AND CLASSIFYING ZINCS.

tor, which has a curved arm from which is suspended a fulcrum on which oscillates a counterpoised lever. One of the extremities of the latter forms an index, and the other supports a wire frame acting as a scale-pan.

When a sheet of zinc is placed on the horizontal supports of this frame, the needle indicates its weight on the dial, and also the number of the series in which it should be classed, according to the dimensions marked at the head of the graduation.

The invention is due to M. Paupier, of Paris.—*Annales Industrielles.*

A PROBLEM IN ATOMIC PHYSICS.

By Prof. J. TYNDALL.

WE must refresh ourselves by occasional contact with the solid ground of experiment, and an interesting problem now lies before us awaiting experimental solution. Suppose 200 men to be scattered equally throughout the length of Pall Mall. By timely swerving now and then, a runner from St. James's Palace to the Athenæum Club might be able to get through such a crowd without much hinderance. But supposing the men to close up so as to form a dense file crossing Pall Mall from north to south: such a barrier might seriously impede, or entirely stop, the runner. Instead of a crowd of men, let us imagine a column of molecules under small pressure, thus resembling the sparsely distributed crowd. Let us suppose the column to shorten, without change in the quantity of matter, until the molecules are so squeezed together as to resemble the closed file across Pall Mall. During these changes of density would the action of the molecules upon a beam of heat passing among them at all resemble the action of the crowd upon the runner?

We must answer this question by direct experiment. To form our molecular crowd we place, in the first instance, a gas or vapor in a tube 38 inches long, the ends of which are closed with circular windows, air-tight, but formed of a substance which offers little or no obstruction to the calorific waves. Calling the measured value of a heat beam passing through this tube 100, we carefully determine the proportionate part of this total absorbed by the molecules in the tube. We then gather precisely the same number of molecules into a column 10·8 inches long, the one column being thus three and a half times the length of the other. In this case also we determine the quantity of radiant heat absorbed. By the depression of a barometric column, we can easily and exactly measure out the proper quantities of the gaseous body. It is obvious that one mercury inch of vapor, in the long tube, would represent precisely the same amount of matter—or, in other words, the same number of molecules—as 3½ inches in the short one; while 2 inches of vapor in the long tube would be equivalent to 7 inches in the short one.

The experiments have been made with the vapors of two very volatile liquids—namely, sulphuric ether and hydride of amyl. The sources of radiant heat were, in some cases, an incandescent lime cylinder, and in others a spiral of platinum wire, heated to bright redness by an electric current. One or two of the measurements will suffice for the purposes of illustration. First, then, as regards the lime light. For 1 inch of pressure in the long tube, the absorption was 18·4 per cent. of the total beam; while for 3·5 inches of pressure in the short tube, the absorption was 18·8 per cent., or almost exactly the same as the former. For 2 inches pressure, moreover, in the long tube, the absorption was 25·7 per cent.; while for 7 inches, in the short tube, it was 25·6 per cent. of the total beam. Thus closely do the absorptions in the two cases run together—thus emphatically do the molecules assert their individuality. As long as their number is unaltered, their action on radiant heat is unchanged. Passing from the lime-light to the incandescent spiral, the absorptions of the smaller equivalent quantities in the two tubes were 23·5 and 23·4 per cent.; while the absorptions of the larger equivalent quantities were 32·1 and 32·6 per cent. respectively. This constancy of absorption, when the density of a gas or vapor is varied, I have called "the conservation of molecular action."

But it may be urged that the change of density, in these experiments, has not been carried far enough to justify the enunciation of a law of molecular physics. The condensation into less than one-third of the space does not, it may be said, quite represent the closed file of men across Pall Mall. Let us therefore push matters to extremes, and continue the condensation till the vapor has been squeezed into a liquid. To the pure change of density we shall then have added the change in the state of aggregation. The experiments here are more easily described than executed; nevertheless, by sufficient training, scrupulous accuracy, and minute attention to details, success may be insured. Knowing the respective specific gravities, it is easy, by calculation, to determine the condensation requisite to reduce a column of vapor of definite density and length to a layer of liquid of definite thickness. Let the vapor, for example, be that of sulphuric ether, and let it be introduced into our 38-inch tube till a pressure of 7·2 inches of mercury is obtained. Or let it be hydride of amyl, of the same length, and at a pressure of 6·6 inches. Supposing the column to shorten, the vapor would

become proportionally denser, and would, in each case, end in the production of a layer of liquid exactly 1 millimeter in thickness.* Conversely, a layer of liquid ether, or of hydride of amyl, of this thickness, were its molecules freed from the thrall of cohesion, would form a column of vapor 38 inches long, at a pressure of 7·2 inches in the one case, and of 6·6 inches in the other. In passing through the liquid layer, a beam of heat encounters the same number of molecules as in passing through the vapor layer, and our problem is to decide by experiment, whether in both cases the molecule is not the dominant factor, or whether its power is augmented, diminished, or otherwise overridden by the state of aggregation.

Using the sources of heat before mentioned, and employing diathermanous lenses, or silvered mirrors, to render the rays from those sources parallel, the absorption of radiant heat was determined, first for the liquid layer, and then for its equivalent vaporous layer. As before, a representative experiment or two will suffice for illustration. When the substance was sulphuric ether, and the source of radiant heat an incandescent platinum spiral, the absorption by the column of vapor was found to be 66·7 per cent. of the total beam. The absorption of the equivalent liquid layer was next determined, and found to be 67·2 per cent. Liquid and vapor, therefore, differed from each other only 0·5 per cent; in other words, they were practically identical in their action. The radiation from the lime-light has a greater power of penetration through transparent substances than that from the spiral. In the emission from both of these sources we have a mixture of obscure and luminous rays; but the ratio of the latter to the former, in the lime-light, is greater than in the spiral, and as the very meaning of transparency is perviousness to the luminous rays, the emission in which these rays are predominant must pass most freely through transparent substances. Increased transmission implies diminished absorption, and accordingly, the respective absorptions of ether vapor and liquid ether, when the lime-light was used, instead of being 66·7 and 67·2 per cent., were found to be—

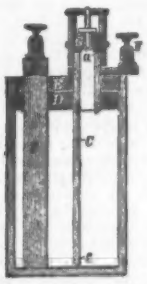
Vapor	33·3 per cent.
Liquid	33·3 "

no difference whatever being observed between the two states of aggregation. This same was found true of hydride of amyl.

This constancy and continuity of the action exerted on the waves of heat when the state of aggregation is changed I have called "the thermal continuity of liquids and vapors." It is, I think, the strongest illustration hitherto adduced of the conservation of molecular action.—*Longman's Magazine.*

IMPROVED FORM OF BATTERY CELL.

KEISER & SCHMIDT, of Berlin, have made some improvements in the zinc carbon single fluid battery cell as shown in the accompanying figure. It differs from others of similar construction in the form of the zinc electrode, C, which is a flat plate from *b* to *c*, where it is immersed in the exciting fluid, while the upper part from *b* to *a* is a hollow cylinder



IMPROVED FORM OF BATTERY CELL, FROM KEISER & SCHMIDT, OF BERLIN.

which passes through the cork lid, D, and a layer of cement at E, and serves for pouring in the liquid. To the upper part of C there is screwed on a valve, G, which permits the escape of gases formed in the cell. F is the pole with its screw cup, B is the carbon rod, and A the glass vessel that contains them.—*Chemiker Zeitung*, No. 24.

LONG DISTANCE SPEAKING.†

I HAVE said that the difficulty in speaking is chiefly due to the environment of the wires employed. Were we to erect a wire from Land's End to John o' Groat's, upon lofty separate poles and away from all other wires, there would be no difficulty whatever in speaking between those two places. Conversation has been held in America over 410 miles; in Persia it has been effected between Tabreez and Tiflis, 390 miles apart; in India, over a distance of nearly 500 miles; in Australia, of 300 miles; but in all these cases it was done either at night or under exceptional circumstances, and in all cases the wires were overground. Had they been underground or submarine, the case would have been very different. Conversations have been held between Dover and Calais, between Dartmouth and Guernsey, and between Holyhead and Dublin, but I know of no case where any persons have spoken through more than 100 miles of submerged cable. The reason of this diminution of speaking distance is due to the electrostatic capacity of the telegraph line, which absorbs the minute quantity of electricity that makes up the currents employed for telephonic purposes.

In every submarine cable, before a signal can be made at the receiving end, the whole cable must be charged up with electricity, and if there be not sufficient electricity sent in to effect this purpose, practically no signal appears at the distant end. With telephone currents on long cables the whole of the electricity is, as it were, swallowed up—that is, none appears at the distant end, or, if it does appear, it is rolled up in one continuous wave, bereft of those rapid variations that reproduce sonorous vibrations. The newspapers said that the sound of the bombardment of Alexandria was heard at Malta; but, in the first place, the experiment was not tried, and even if it had been tried, it could not have succeeded. The use of underground wires very seriously impedes telephonic extensions, and with our present apparatus and present knowledge we cannot readily speak over greater distances than 20 miles.

Disturbances.—But there are other disturbing influences at work of more serious import.

When two or more telephone wires run side by side, what is said on one can be overheard on all the others; and when a telephone wire extends alongside telegraph wires, every current on the telegraph circuit is repeated in the telephone, leading to a hissing, frying, bubbling sound that is not only very irritating, but which on busy lines entirely drowns speech. When music is transmitted on one wire, it can be heard equally well on all wires running parallel and contiguous. This is due to induction and to leakage.

(A). *Induction.*—Induction is a term employed to designate the peculiar influence which electrified and magnetized bodies exert upon conducting and magnetic masses in their neighborhood. If two wires run side by side for some distance, every current of electricity sent upon one wire will produce two currents in the contiguous wire, the one at the commencement and the other at the end of the primary current of electricity. The greater the intensity, and the more sudden and abrupt the commencement and the ending of the inducing current, the greater effect it has on the induced wire. Those instruments, consequently, which reverse their currents the most rapidly and suddenly, produce the greatest disturbance. The powerful alternative and intermittent currents used for certain electric light systems are death to telephones; they cause an incessant roar that renders speech an impossibility. There are some apparatus in telegraphy that require very powerful currents to work them, which are equally detrimental. Many attempts have been made to cure this evil.

1. The sensitiveness of the receiver has been reduced to lessen the influence of the disturbing currents, and the strength of the telephonic transmitting currents has been increased so as to overpower the induced currents.

2. The influence of one wire on the other has been screened off by inserting metal coverings in connection with the earth between them.

3. The suddenness of the rise and fall of the inducing currents has been modified by the insertion of condensers or electro magnets.

4. Counterbalancing or neutralizing effects have been set up by counter induction apparatus.

But all these plans, and many others, have been proved either only partially successful or wholly abortive. The only effective mode of curing the evil at present practically used is to employ a complete metallic circuit so contrived that the two wires are in very close proximity to each other, or that they twist round each other so as to maintain a mean average equality of distance between themselves and the disturbing wires. When we have the two wires of a circuit kept at the same mean distance from the disturbing causes, however near they may be, the influence on each must be identically the same; and as the one is used for going and the other for returning, the similar influences must be opposite in direction, and they must therefore neutralize each other. This plan, which was originally devised for underground wires by Mr Brookes, of Philadelphia, was found to be absolutely true in practice, and the Post Office, having laid down many hundreds of miles on this system with perfect success, invariably constructs its circuits both underground or overground in this way. It is, of course, more expensive than a single wire, but the great gain—the absolute freedom from overhearing, the privacy, and the absence of crackling—is well worth the extra cost. Wires in submarine cables are invariably laid up with a twist, so that no special contrivance is needed on such wires, and in underground wires not laid up together as cables they are, as a rule, so close to each other that twisting is unnecessary; but for overground purposes twisting is essential, and special arrangements have to be carried out. Professor Hughes showed how this was to be done, and Messrs. Moseley carried it out practically in the neighborhood of Manchester. The plan adopted by the Post Office for *two* and for *four* wires is shown by the diagram. It is simply and easily carried out, and entails no practical difficulty whatever.

In the neighborhood of Manchester there are over 400 miles of overground double wire twisted on this plan, working efficiently and thoroughly. I have spoken to a friend 76 miles off, through wires that were erected on poles carrying busily occupied telegraphic currents, without disturbance or difficulty.

(B.) *Leakage.*—The double wire system is only absolutely effective so long as the insulation is good. The moment insulation fails, connection with the earth is made, and then we have disturbing causes due to currents flowing through the ground, which are increased in proportion to the deterioration of the insulation. Hence, good insulation is essential to telephone working.

Speaking without wires.—The discovery of the telephone has enabled us to establish beyond doubt the fact that currents of electricity actually traverse the earth's crust. The theory that the earth acts as a great reservoir for electricity may be placed in the physicist's waste paper basket, with phlogiston, the materiality of light, and other hypotheses. Telephones have been fixed upon a wire passing from the ground floor to the top floor of a large building, the gas pipes being used as a return, and the Morse signals sent from a telegraph office 250 yards away have been distinctly read; in fact, if the gas and water systems be used, it is impossible to exclude telegraphic signals from the telephone circuit. There are several cases on record of telephone circuits miles away from any telegraphic wires, but in a line with the earth terminals, picking up telegraphic signals. When an electric light system uses the earth, it is stoppage to all telephonic communication in its neighborhood. The whole telephonic communication of Manchester was one day broken down from this cause, and in the City of London the effect was at one time so strong as not only to destroy telephonic communication, but to ring the bells. A telephone circuit using the earth for return acts as a shunt to the earth, picking up the currents that are passing, in proportion to the relative resistances of the earth and the wire. The earth offers resistance, and consequently obeys the law of Ohm; hence it is not only essential for a telephonic system that the earth should not be used on any electric light system, but it is also desirable that the earth should be eschewed for telephonic purposes. Thus, the double wire system adopted by the Post Office and by the Société Générale des Telephones of Paris not only cures the ill effects of induction, but it materially diminishes the disturbing influences of earth conduction. The four wire system of the Post Office effectually checks leakage from one wire to the other—cross contact, as we call it in England—for each wire of the same current is always on a different supporting arm.

A telephone circuit when in connection with the earth gives distinct evidence of every visible flash of lightning, however far off the thunder storm may be. No difference in time has been observed between seeing the flash and hearing the crash.

It is said that, if a telephone be connected between the gas and water systems of a house, distinct evidence of every flash can be heard. There have been several cases of persons being knocked down while experimenting during a thunderstorm, but no personal injury has been sustained, although the apparatus itself is frequently damaged. In England, at present, we have not found the damage done sufficient to justify the employment of lightning protectors. The use of double wires diminishes the danger to a minimum. On the continent and in America, however, where one wire only is used, telephones are invariably protected by lightning arresters.

There are certain natural currents flowing through the crust of the earth. They are called "earth" currents, and at times acquire such considerable energy that, with a telephone pressed to each ear, I have been told, although I have not experienced it, the noise made is as though "your brains were boiling." This is due to the intermittent currents produced by the polarization of the earth plates.

M. Van Rysselberghe has recently spoken between Paris and Brussels upon a wire nearly 200 miles long, which was used at the same time for ordinary telegraphy, but the experiment was made early in the morning (4 A.M.), and was effected by retarding the telegraphic currents, so as to modify the suddenness of their rise and fall by means of condensers and electro-magnets. I am unable to understand the advantage of any gain in speaking on a wire which is detrimental to telegraphic communication. Speed is of more importance than speech, and we can telegraph much faster than we can speak. In England speed is everything, and we eliminate every influence that retards speed—condensers and electro-magnets in telegraph circuits are out of the question. M. Van Rysselberghe has endeavored to extend the idea to cure the effects of induction by destroying the main cause of the disturbance—that is, by reducing the sudden rise and fall of the prime telegraphic currents; but to do this means to retard telegraphy, and we cannot afford in England to cripple the one system in order to benefit the other.

I have recently tried an extremely interesting experiment between this place (Southampton) and the Isle of Wight, namely, *to communicate across seas and channels without the aid of wires at all.* (Fig. 1.) Large metal plates were im-

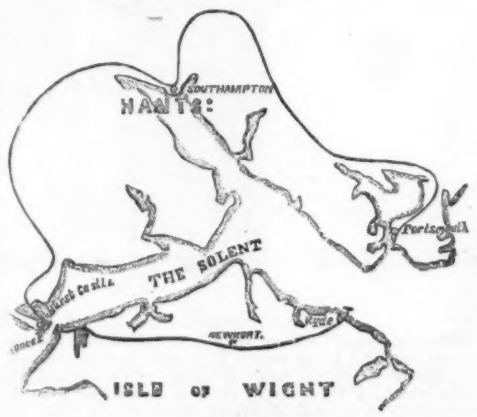


FIG. 1.

mersed in the sea at opposite ends of the Solent, namely, at Portsmouth and Ryde, six miles apart, and at Hurst Castle and Seonce Point, one mile apart. The Portsmouth and Hurst Castle plates were connected by a wire passing through Southampton, and the Ryde and Sconce Point plates by a wire passing through Newport; the circuit was completed by the sea, and signals were passed easily so as to read by the Morse system, but speech was not practical.

DOMESTIC ELECTRICITY.

AMONG the most valuable, and, up to the present time, the least generally appreciated, services that electricity can render for domestic purposes is that of its application in lighters. At the present epoch of indifferent matches, to have instantaneously a light by pulling a cord, pressing on a button, or turning a cock is a thing worthy of being taken into serious consideration; and our own personal experience permits us to assert that, regarded from this point of view, electricity is capable of daily rendering inappreciable services.

According to the nature of the application that is to be made of them, the places in which they are to be put, and the combustible that they are to inflame, etc., electric lighters vary greatly in form and arrangement.

We shall limit ourselves here to pointing out the simplest and most practical of the numerous models of such apparatus that have been constructed up to the present time. All those that we shall describe are based on the incandescence of a platinum wire. A few have been constructed based on the induction spark, but they are more complicated and expensive and have not entered into practical use. Before commencing to describe these apparatus we shall make a remark in regard to the piles for working them, and that is that we prefer for this purpose Leclanche elements with agglomerated plates and a large surface of zinc.

In order to bring about combustion in any given substance, it is necessary to bring near it an incandescent body raised to a certain temperature which varies with the nature of the said substance, and which is quite low for illuminating gas, higher for petroleum, and a white heat for a wax taper or a candle. We have said that we make use exclusively of a platinum wire raised momentarily to incandescence by the passage of an electric current. The temperature of such wire will depend especially upon the intensity of the current traversing it; and, if this is too great, the platinum (chosen because of its inoxidizability and its elevated melting point) will rapidly melt; while, if the intensity is too little, the temperature reached by the wire will itself be too low, and no inflammation will be brought about. Practice soon indicates a means of obviating these two inconveniences, and teaches how each apparatus may be placed under such con-

* The millimeter is 1-25 of an inch.

† Abstract from a paper by Wm. H. Preece, read before the British Association.

ditions that the wire will hardly ever melt and that the lighting will always be effected. For the same intensity of current that traverses the wire the temperature of the latter might be made to vary by diminishing or increasing its diameter. A very fine wire will attain a red heat through a very weak current, but it would be very brittle and subject to break at the least accident. For this reason it becomes necessary to employ wires a little stronger, and varying generally from one to two tenths of a millimeter in diameter. The current then requires to be a little intenser. The requisite intensity is easily obtained with elements of large surface, which have a much feebler internal resistance than porous cup elements; and since, for a given number of elements, the intensity of the current decreases in measure as the internal resistance of the elements increases, it becomes of interest to diminish such internal resistance as much as possible.

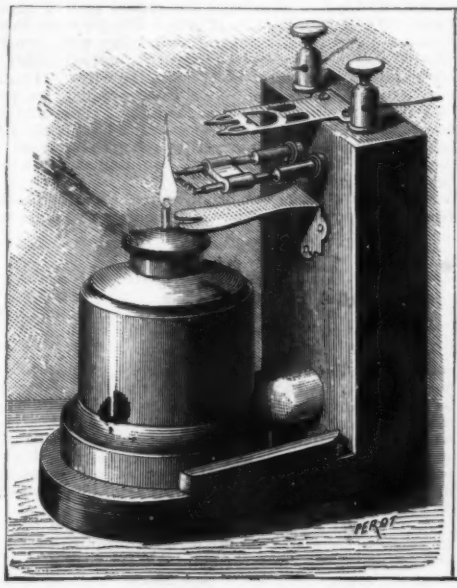


FIG. 1.—ORDINARY NAPHTHA LIGHTER OF MR. LOISEAU.

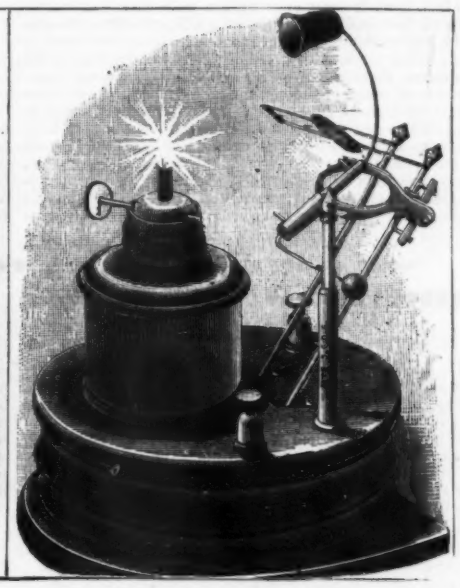


FIG. 2.—RANQUE'S NEW FORM OF LIGHTER WITH EXTINGUISHER.

The platinum wires are usually rolled spirally with the object in view of concentrating the heat into a small space in order to raise the temperature of the wire as much as possible. There is thus need of a less intense current to produce the inflammation than with a wire simply stretched out. In fact, the same wire traversed by a current of constant intensity scarcely reaches a *red* heat when it is straight, while it attains a *white* heat when it is wound spirally, because, in the latter case, the cooling surface is less.

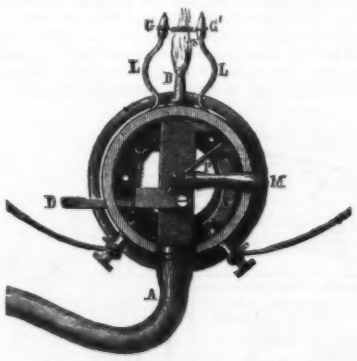


FIG. 3.—BARBIER'S LIGHTER.

We shall now proceed to the examination of a few practical forms of electric lighters.

In Fig. 1 will be seen quite a convenient spirit or naphtha lighter, which has been devised more especially for the use of smokers. By pushing the lamp toward the wall the wick is brought into proximity with the spiral, and the lamp, acting on a button behind it, closes the current. Pressure on the lamp being removed, the latter moves back slightly through the pressure of a small spring which thrusts on the button. Owing to this latter simple arrangement, the spiral never comes in contact with the flame, and may thus last for a long time. Mr. Loiseau, the proprietor of this apparatus, employs a very fine platinum wire flattened into the form of a ribbon, and it takes only the current from a *single element* to effect the inflammation of the wick. The system is so arranged that any one can easily replace in a moment the spiral that has accidentally gotten out of order; and, in order that this may be done, the maker has placed the spiral on a small distinct piece that he styles the "conflagrator." The latter consists of two small thin tubes of brass held parallel and firmly by means of a brass cross piece. A small bit of paper wound around each tube in front of the cross-brace insures of insulation. The outer extremity of the two tubes supports the platinum spiral, which is fixed to them very simply by the aid of two small brass needles of conical form, which pinch the wire in the tube and hold it in place. There is nothing easier to do than replace the wire. All that is necessary is to remove the two little rods with a pair of pincers; to make a spiral of suitable length by rolling the wire round a pin; and to fix it into the tubes as we have just explained. With two or three extra "conflagrators" on hand there need never any trouble occur.

In Fig 2 we show a new and simple form of Mr. Ranque's lighter, in which an electro-magnet concealed in the base brings the spiral and the wick into juxtaposition. The extinguisher, which is balanced by a counterpoise, oscillates about a horizontal axis, and its support carries two small pins against which act successively two notches in a piece, of oval form, fixed on the side of the movable rods.

In the position shown in the cut, on the first emission of a current the upper notch acts so as to depress the extinguisher, but the travel of the rods that carry the spiral is so limited that the latter does not strike against the extinguisher. On the next emission the lower notch acts so as to raise the extinguisher while the spiral approaches the wick and lights it. It is well to actuate these extinguishing lighters, which may be located at a distance, not by a contact button, but by some pulling arrangement, which is always much more easy to find in the dark without much groping about. There might be used for such a purpose the very motion of the front door, when opened, for lighting the hall; but that would offer the inconvenience of operating likewise in the day time, and of thus needlessly using up the pile and the naphtha. In all these spirit or naphtha lighters it is important that the spiral *shall not touch* the wick, but that it shall be placed a little above and on the side, in the mixture of air and combustible vapor.

FIG. 4.—LOISEAU'S GAS LIGHTER.

Several apparatus have likewise been devised for lighting gas by electricity, and a few of these we shall describe.

The simplest form (Fig. 3) of these is Mr. Barbier's lighter for the use of smokers, for lighting candles, sealing letters, etc. It consists of a small gas burner, B, affixed to a round box 7 to 8 centimeters in diameter, and connected to the gas pipe by a rubber tube, A. By maneuvering the handle, M, the cock is opened and an electric contact set up of sufficient duration to raise to a red heat the spiral, GG', and to light the gas. It is well in this case, for the sake of economizing in wire, to utilize the lead gas pipe as a return wire, especially if the pile is located at some little distance from the lighter. In the arrangement shown in the cut the key is provided with a special spring which tends to cause it to turn in such a way as to assume a vertical position, and with a tooth, which, on engaging with a piece, D, moving on a joint, holds it in a horizontal position as soon as it has been brought thereto. In order to extinguish the burner, it is only necessary to depress the lever, D, and thus allow the key to assume again the vertical position, that is to say, the position that closes the aperture through which the gas flows out. In the new arrangement, the notch, spring, and the lever, D, are done away with, the cock alone taking the two positions open or closed.

FIG. 5.—LIGHTER FOR GAS FURNACES.

Another very ingenious system is that of Mr. Loiseau (Fig. 4), consisting of an ordinary gas burner (fish-tail, butswing, etc.), carrying at its side a "conflagrator," analogous to that of the spirit lighter (Fig. 1), but arranged vertically. One of the rods of the conflagrator is connected with the positive of the pile, and the other with the little horizontal brass rod which is seen at the bottom of the figure. On turning the cock so as to open it, a small flow of gas occurs opposite the platinum spiral, while at the same time a rigid projecting piece affixed to the cock bears against a small vertical metallic piece and brings it in contact with the brass rod.

The circuit is thus closed for an instant, the spiral is raised to a red heat and lights the gas, and the flame rises and finally lights the burner. It goes without saying that on continuing the motion the contact is broken, so as not uselessly waste the pile and so as to stop the escape of gas.

For gas furnaces Mr. Loiseau is constructing a *handle lighter* (Fig. 5), which is connected with the side of the furnace by flexible cords. The contact button is on the sleeve itself, and the spiral is protected against shocks by a metallic covering which is cleft at the extremity, and the points bent over at a right angle. All the lighters here described work well and are rendering valuable services. They may be considered as the natural and indispensable auxiliaries of electric call bells, and their use has most certainly been rendered practical through the Leclanche pile.

THE ELECTRIC TRICYCLE.

THE accompanying illustration represents Professors Ayrton and Perry's tricycle, which is both electrically lighted and propelled by means of a secondary battery. M is their electro-motor, placed underneath the seat, and the spindle of which is geared with the driving wheel of the tricycle, 44 inches in diameter, by means of the pinion, P, and large toothed wheel. The pinion has 12 teeth on it, and the large

THE ELECTRIC TRICYCLE.

toothed wheel 248, so that the motor turns about twenty times as fast as the tricycle wheel, or makes about 1,200 revolutions per minute when the tricycle is going at eight miles an hour. The secondary battery, S, which in the various runs has been composed of Faure cells, Sellon-Volckmar cells, and lastly of a combination of the two, is carried on a small wooden platform, suspended from the backbone of the tricycle. By means of a commutator, C, seen at the left hand side of the rider's seat, and worked with his left hand, the number of accumulators in circuit with the electro-motor can be varied at will, and the speed of the tricycle altered accordingly. B is the handle of the ordinary brake, which can be applied with the left hand immediately after turning off the current with the commutator, C. Since by means of this commutator the full power of the accumulators can only be turned on by passing through the intermediate powers, shocks to the tricycle and rider are not experienced at starting. A is one of Profs. Ayrton and Perry's ammeters, which measures at every moment the main current, and V is one of their voltmeters, the readings on which continuously show the electromotive force between the terminals of the motor, so that from the readings on the two instruments the rider can calculate at any moment the horse power that is being expended in propelling the tricycle. L L are two small incandescent lamps of about four candle power each, and which are illuminated by a small current produced by two of the accumulators used also for the driving. The lamps are placed in the position shown, partly for the purpose of illuminating the track, and partly to light the ammeter and voltmeter.

The motor employed is one of their ordinary half horse power patent motors, weighing 45 lb., the smallest one that was completed when the tricycle was fitted up, but it is obvious that it is unnecessarily powerful for driving a tricycle. The smallest weight of accumulators that they have yet employed to produce a speed of six miles an hour on the level is 150 lb., and which contains a store of electric energy equal to about two horse-power hours. With this load the tricycle will not only propel itself, but, when going slowly, will exert an additional pull of about 33 lb., as measured by a spring balance attached to its back, and held by a person attempting to resist the motion of the tricycle. With a somewhat larger weight of accumulators they have maintained a speed of eight miles an hour for a considerable time with a man of average weight riding. The tricycle is an ordinary one, con-

verted to this new use by taking off the treadles and chain gearing and replacing it with the electric arrangements seen in the figure, but we understand that the designers, encouraged by the success of the converted vehicle, are at present engaged on a tricycle specially suited for being electrically propelled, and in which, among other improvements over the present machine, will be so arranged that not merely the rider but also the accumulators will be hung on springs. In their present form of electric tricycle, the ordinary treadles to be worked by the feet are entirely absent, but in their first form the treadles were left on so that the feet and the electric propulsion could, when going up steep hills, be used to help one another, an advantage which may lead them, we are told, to introduce foot treadles as a supplement to the main electric driving power in their third and newest form of electric tricycle.—*Electrical Review.*

AUTOMATIC TELEGRAPHY.

THE AMERICAN RAPID TELEGRAPH COMPANY'S SYSTEM.

NOT many of the readers of *The Operator*, perhaps, are aware of the extent to which automatic telegraphy has been developed in this country by the American Rapid Company. We have thought that some account of the work of the company, together with a description of its system, might be of interest.

By this system, as at present organized, messages are taken from the receiving counter and carried by pneumatic tubes or messengers to an operator working an Anderson perforating machine, of which there are usually six to eight required to prepare the dispatches for one busy wire. The perforated slips are handed by the perforating operator to a transmitting operator, who winds the paper slip, usually containing five dispatches at a time, on a spindle and then passes it rapidly through the transmitter, to be described hereafter. This process transmits the message over the wire, at an average rate of 400 words per minute, to the distant station, where it is recorded in blue dots and lines on a strip of yellow paper. This strip is handed to an operator working a Remington type-writing machine, by whom it is translated, and written on the delivery blank in Roman characters.

Taking the business of one day, haphazard, on the Boston wire, the actual performance was as follows: 4,000 messages were sent between 8 A.M. and 6 P.M., on one wire, and the average time consumed in perforation, transmission, translation, and delivery was nine minutes per message. Some of these messages were received at branch offices in New York and delivered through branch offices in Boston.

One perforating operator will average 300 messages per day, while a type-writer will handle 240 messages. The best average time made by the perforators is 45 words per minute, and by the type-writers, who translate from Morse characters as they write, 30 words per minute.

Some idea of the magnitude of the business of the New York office may be gathered from the following statistics: There are entering this office 17 main wires and 44 loops, and there are employed 9 automatic operators, 38 Morse operators, 20 perforators, 24 type-writers, and 34 clerks and messengers. The delivery department employs 150 messengers. 36 Morse instruments, 1,000 cells of carbon and 1,000 cells of Callaud battery are also in constant use. The office handles an average of 11,500 messages per day. There are 38 more operators employed in 33 branch offices in this city, some of which work direct with distant points; the remainder send their business on Morse wires to the main office. The business of the main office is directed by Messrs. George A. Hinman, manager and city superintendent; Samuel K. Dingle, chief operator; H. J. Malone, chief operator of city lines; E. L. Rockwell, traffic chief; and E. W. Venable, night manager.

It remains now to describe the apparatus and electrical arrangements used to transmit Morse characters over long lines, reaching to Boston, Buffalo, Pittsburg, and other distant places. The chief obstacle to high speed of transmission on long lines is static induction, and this is the rock on which most fast systems have split. By static induction is meant that condition of a long and well insulated conductor which follows when the circuit is closed for an instant, and the current from a battery flows out to line and the circuit is then opened again and the current interrupted. It is found that the conductor absorbs a charge of electricity somewhat in the fashion that a sponge absorbs water, and retains it for an appreciable length of time, unless some special means are used to squeeze it out again, and thus clear the line for the reception of a second current. It therefore becomes necessary, in order to produce rapidly returning signals at the distant end of a wire, first to electrify the wire by some convenient source of electricity, and then to rapidly discharge or neutralize this charge and restore the wire to its original condition of non-electrification, in order to produce a second signal by a second charge. On some lines, such as submarine cables, the non-electrified or neutral state is never completely produced, but, instead, the existing charge is very much weakened and the signals are produced by the difference between high and low electrical states, the difference between the two conditions being the actual working margin, and the greater this difference the clearer and more distinct are the signals received.

It follows, from what has been said, that if a current be sent to line from the copper or carbon pole of a battery for a length of time sufficient to produce a Morse dot at the distant end, the tendency will be for it to prolong itself and to produce, relatively speaking, in a rapid system where the signals follow one another with great velocity, a Morse dash. But if the emission of the copper current be succeeded immediately by a short zinc current, the charge remaining in the wire will be neutralized, the false "tail" of the dot bitten off, so to speak, and a dot will be produced at the distant end. Now, on the other hand, if it be desired to send a dash, it is only necessary to send two dots in rapid succession, before a reverse current is transmitted, to insure a sufficient elongation of the dot currents to produce a dash at the distant station. Both of these principles have been very ingeniously used in devising the apparatus used by the American Rapid Company, and we shall now explain the details of the machinery in actual operation.

FIG. 1

First, it should be stated that, for reasons foreshadowed in the above theoretical considerations, the spaced letters of the ordinary Morse alphabet cannot be conveniently used in this system, and the following characters have therefore been substituted for them:

C	— — · ·	Z	· · · — ·
R	· — ·	&	· · · · —
L	· — —	Th	· · · · ·
O	— — —	St	— · · · ·
Y	— · — —		

The combinations *th* and *st* are each assigned a separate character, on account of their frequent recurrence in ordinary English. The Roman system of notation is used for the transmission of numbers, and there are no numerals in the code.

FIG. 2.

The perforating machine is an apparatus about the size of an ordinary sewing machine table, having in front all of the keys necessary, one for each letter or combination of letters in the alphabet. These keys, when depressed, actuate a set of punches, which perforate a series of round holes in a moving fillet of paper. There are no dashes in the perforated slip, dashes being represented by a succession of dots on the same side of the slip. Steam power, transmitted by belts and pulleys, operates the punches, feeds the paper, and determines the movement of the punches either against the upper or lower margins of the paper, the sole function of the operator being to depress the proper key. A space character, represented on the slip by four successive dots, is perforated after each letter, and two of such space characters are sent after each word. Fig. 1 shows the first nine letters of the alphabet, in the regular order of the letters in English, as perforated and ready for actual transmission.

It will be observed that no two dots occur in succession on the same line, unless they are intended to represent a dash, and that two groups of two dots in succesion, intended to represent two dashes in succession, are placed on opposite lines.

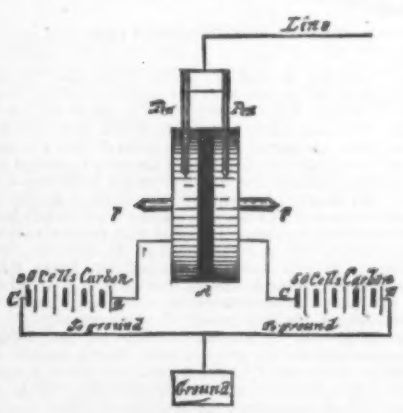


FIG. 3.

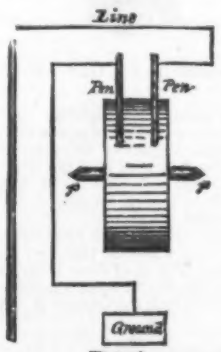


FIG. 4.

Fig 2 shows the same characters, as received on the chemical paper in the distant end of the line. By comparing Figs. 1 and 2, the exact reproduction in Fig. 2 of the perforations in Fig. 1 will be observed; but a short description of the letter *a*, as an example, will perhaps make the matter clearer.

The first dot of the *a* in Fig. 1, perforated in the lower line, allows of one emission of say a zinc current by the transmitter, and is reproduced as the first dot in the upper line in Fig. 2. This would be "tailed" out into a dash by the static charge of the line, were it not immediately followed by a copper current sent by the transmitter when the first dot on the upper line comes under the transmitting pen. This dot is immediately succeeded by another dot, and these two dots "tail" into a dash, as shown immediately after the dot in Fig. 2, in the lower line of characters. This forms the complete *a*, but this last dash would "tail" out into an indefinite and uncertain length were it not followed by the four spacing dots in the lower line (Fig. 1), which tail into the long spacing dash in the upper line of Fig. 2. These are succeeded by an opposite current to produce the letter *b*, and so on indefinitely, so that each element of a Morse character, no matter whether it be a dot or a dash, is produced by a different and opposite current from that of the element which precedes it, and from that of the element which follows it. It is to this device that much of the success of the system is due, and it should be understood that this reversal of the signs is produced automatically by the perforating apparatus, independent of the will of the operator.

We will now describe the transmitting apparatus by which these currents are sent to line. Fig 3 is a diagram of the transmitting wheel, pens, and connections. A represents a platinum faced metallic wheel divided longitudinally by a disk of ebonite into two portions electrically, and pivoted at *pp*. This wheel is revolved rapidly by a crank worked by hand, and one side is in electrical connection with the zinc pole of a battery of 50 carbon elements, while the other half of the wheel is in contact with the carbon pole of another battery of the same number of cells. The pens are formed by a metallic frame in electrical connection with two steel wires. The perforated slip of paper is carried rapidly by friction rollers between the wheel and the wires. It will be seen at a glance how this arrangement produces the pulsations of the requisite polarity at the distant end. The pens make contact with the wheel whenever a hole in the paper passes under one of them, while the pens are insulated from the wheel by the paper, in the spaces of unperforated paper between the holes.

Fig. 4 shows the receiving apparatus. A is a platinum faced wheel, pivoted at *pp*. The pens are two steel wires connected to line and ground respectively. Chemically prepared paper is drawn rapidly between the wheel and the pens by suitable mechanism operated by hand, and the passage of the currents from the line pen through the paper, wheel, and ground pen stains blue marks on the paper as long as the current flows. The solution used to prepare the paper is composed as follows: Nitrate ammonia, 2 lb.; muriate ammonia, 2 lb.; ferricyanide of potassium, 1 oz.; water, 1 gallon.

In the actual working of the system the Morse key and sounder and Siemens relay are used for calling, answering, and giving "O K." to messages. A transmitting machine, receiving apparatus, and complete Morse set are mounted on one table, and are attended by a Morse operator and an assistant, usually a girl, who operates the receiving apparatus.

Fig. 5 shows the connections and arrangements of the three sets of apparatus on one table, being a complete set of the electrical apparatus required for one wire. Of course, sending and receiving go on alternately, usually five messages at one time being exchanged.

An inspection of the diagram will show how the connections are made and the course of the current through the three different sets of apparatus, as the switches are turned. The transfer switches, with the levers 1, 2, and 3, are used for connecting the line and battery wires with the Morse automatic sending or automatic receiving apparatus respectively. They are so arranged that a movement in one direction places levers 1 and 2 of the same switch in metallic connection with each other, leaving lever 3 insulated; while a movement in the other direction places levers 1 and 3 in similar connection, leaving lever 2 insulated. A pivot arm attached to the switches causes the pens to be lifted from the receiving and transmitting wheels with the same movement that shifts the switches. The switch below the Morse key is used in the same manner as the ordinary circuit closer of a Morse key, although its connections are different. A movement toward the spectator connects its lever to the lower stud, and the key is then ready for Morse sending. A movement toward the top of the sketch connects the lever with the upper stud, and the key lever then rests on its back contact, but is disconnected from the main line, and therefore does not affect the course of currents through the automatic portions of the apparatus. The transfer switches, with levers 1, 2, and 3, are moved toward the bottom of the drawing, and levers 1 and 3 are thereby placed in contact for Morse transmission and receiving; the right hand switch is moved toward the top of the drawing, and levers 1 and 2 are thereby placed in contact for automatic transmission; the left hand switch is placed with levers 1 and 2 in contact for automatic reception. The course of the current can readily be traced by the aid of the diagram.—*The Operator.*

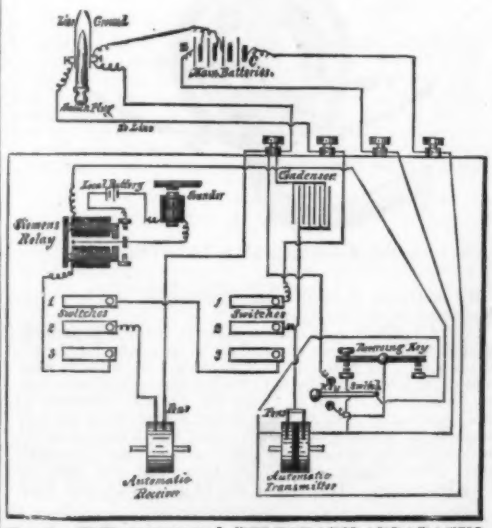


FIG. 5.—THE CHEMICAL TELEGRAPH APPARATUS.

A NEW DEVELOPER FOR GELATINE PLATES.

By M. CHARDON.

Water	100 c. c.
Oxalate of potass	20 grammes.
Lactate of iron	10 "
Bromide potass	0.10 "

EMULSION FOR OPAL PRINTING.

FOR opal work a much thinner emulsion is necessary than for transparencies or negatives; that is to say, an emulsion containing a smaller proportion of silver to gelatine is requisite. The quantities given below are calculated for opal printing. If it be desired to use the emulsion for making transparencies or for reproducing negatives, then the same quantities of salts must be added to one-half the quantity of gelatine and water.

In order to make five ounces of emulsion, we take from eighty to one hundred grains of gelatine according to its character, fifty grains of silver nitrate, and water as required. To convert this quantity of silver and leave an excess of the other salt, the following proportions of each must be used: Of chloride of ammonia, 18 grains; of citrate of potash, 35 grains; of neutral oxalate of potash 35 grains; and of carbonate of soda, 17 grains. This last quantity refers to the anyhdrous carbonate of soda, which is recommended in preference to any other. Common washing soda contains so many impurities and such variable quantities of water of crystallization that it is placed entirely out of court when precision is at all desirable. Bicarbonate of soda, though less to blame in these respects, offers the inconvenience of producing a considerable effervescence, which is frequently a great nuisance.

As we stated last week, each of the different silver salts we have named gives a variation in tone and in other minor peculiarities. The following are some of the combinations we have found to answer well. The first is citro-chloride. Here we take

Chloride of ammonium	10 grains.
Citrate of potash	15 "
Gelatine	80 to 100 "
Water	4 ounces.
Silver nitrate	50 grains.

This emulsion is made in the ordinary manner, apportioning the water between the ingredients as may be most convenient. Having been kept warm and liquid for from half an hour to an hour, it is precipitated by means of alcohol, the precipitate rinsed for a few minutes in water and remelted, and made up to five ounces. This gives an image of a rich purple color before toning, which may be varied a good deal by introducing minute traces of free acid or ammonia respectively into the emulsion.

The next formula is a combination of chloride with oxalate of silver, and is as follows:

Chloride of ammonium	10 grains.
Neutral oxalate of potash	15 "
Gelatine	80 to 100 "
Water	4 ounces.
Silver nitrate	50 grains.

These are mixed and the emulsion precipitated in the same manner as with the citro-chloride; or, if preferred, an emulsion of precipitated carbonate of silver may be converted by the addition of hydrochloric and oxalic acids, but perhaps the first plan is the better.

This gives an image of a color much more approaching to brick red, and at first sight not by any means a pleasing tint; but it tones with surprising readiness, and with very little gold.

The next formula contains chloride in combination with both citrate and oxalate, and it is as follows:

Chloride of ammonium	6 grains.
Citrate of potash	15 "
Oxalate of potash	10 "
Gelatine	80 to 100 "
Water	4 ounces.
Silver nitrate	50 grains.

Here, again, the plan of mixing in the ordinary way and precipitation with alcohol is perhaps more convenient than the conversion of the washed carbonate of silver, though in all cases the combinations can be made by mixing the different emulsions in proper proportions.

This emulsion gives results midway between those obtained with the other two, the image being of a bright cherry red and toning with remarkable facility. As regards sensitiveness, the citro-chloride is the most rapid—probably twice as quick as ordinary albumenized paper—and the oxalo-chloride the slowest, the last given formula occupying a midway position.

As regards the manipulation: on coating the plates there is little to be said, except that a thicker coating is desirable upon polished opal than upon the matte surface. With the formulæ given, the plate may be covered and the surplus poured off without draining closely.

The printing is carried some little deeper than it is required to be when finished, but care should be taken not to carry it too far, or a heavy and unpleasant effect will be given.

After printing, if the films be soaked in water the usual milky appearance will be given, showing that the citrate and oxalate are partly soluble. If, therefore, the plates be placed directly into the toning bath, the latter would be rapidly put out of order. It is necessary, therefore, though there is no free nitrate present, to wash very thoroughly; but, as the removal of the feebly soluble citrate and oxalate would be a very long operation if conducted in the ordinary way, it is better to use a ten or fifteen grain solution of salt, which will rapidly convert the citrate or oxalate into chloride of silver, without in any way affecting the toning operation.

The toning is conducted in the same manner as albumenized paper; but, perhaps, greater care is necessary to avoid overtoning. We have succeeded best with a comparatively weak solution of gold—one grain to ten ounces of solution. The acetate, carbonate, and tungstate baths answer equally well; but we prefer the borax bath—five grains of borax to each grain of gold.

Fix in hypo. one part to five of water, and wash as well as for a gelatine negative, finishing off with a dip for a few seconds into saturated solution of alum to harden the film; rinse again and dry.

It is scarcely needful to say that the toning and fixing baths must be used cold.—*British Journal of Photography.*

NEW SEWAGE PROCESS.—A company has been formed at Liege for working the patent of M. Neujean. This inventor proposes to purify sewage by filtering it through the basic slags of the Bessemer process, which contain calcium phosphate. These slags are said to withdraw from the sewage the organic and especially the nitrogenous matter, as well as a part of the mineral impurities, whether dissolved or suspended. The slags are then converted into superphosphate by treatment with sulphuric acid. Analytical confirmation is wanting.

A CONVENIENT AND DELICATE TEST FOR ALBUMEN.

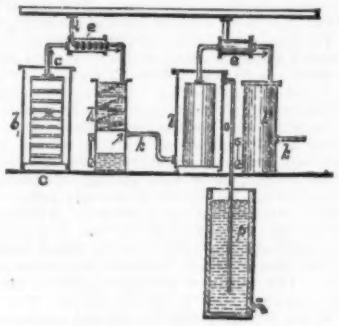
DR. A.W. ABBOTT, of Minneapolis, Minn., sends us the following description of an easy and delicate method of testing albumen:

"Pour a few drops of urine gently down the inside of a glass vessel containing acidulated water at the boiling point. If albumen be present, a more or less dense cloud will form just at the dividing line between the fluid tested and the clear water above. As the contrast in opacity is between the clear water and the milky albuminous cloud, the test is very delicate, one-twentieth of one per cent. of albumen making a very perceptible clouding. It has all the advantages of the ordinary heat and acid test and Heller's nitric acid test. It is even better than the latter in a cloudy fluid, as in urine, with urates in excess, because the clear water above makes a perfect medium in which to detect the faintest cloud, while the layer of coagulated albumen in Heller's test may be entirely obscured by the opacities in the fluid itself. If no test-tube or nitric acid is at hand, pour boiling water into a common tumbler, let it stand a moment to insure the heating of the bottom of the tumbler, empty, refill, acidulate with *vinegar*, and proceed as before. While this is a modification of the heat and acid test, it has the advantage of being applicable under all possible circumstances, whether special apparatus is at hand or not. It is as convenient and accurate in the farmhouse as in the laboratory."—*Medical Record.*

APPARATUS FOR THE PRODUCTION OF OXYGEN BY DIALYSIS OF ATMOSPHERIC AIR.

THE following is a description of a method of producing oxygen invented by M.P. Margis, of Paris, as given in the *Journal* of the Society of Chemical Industry:

The air is drawn through membranes, through which the oxygen passes in larger quantity than the nitrogen. They consist of bags of taffeta which have been soaked in a solution of 50 parts by weight of caoutchouc, dissolved in 400 parts of carbon disulphide, 20 parts alcohol, and 10 parts ether. The bag, *a*, which is stiffened by iron rods, is, placed in an iron cylinder, *b*, the air entering through its perforated bottom. The exhausting action is produced by the injector, *e* working with steam. The gas passes from *a* to *e* mixed with steam, then through the cooling apparatus, *h*, where the steam is condensed, while the gas, rich in oxygen, goes through the pipe, *k*, into the second dialyzer, which is arranged like the first one, excepting that the outer cylinder, *l*, is closed. The non-dialyzed nitrogenous air leaves the apparatus through the pipe, *o*, which dips in the water tank, *p*. The height of



the column of water in *p* regulates the pressure in the cylinder, *l*. After dialyzing four times, the gas collected in a gasholder contains 95 per cent. oxygen. The gas from the first dialyzer shows 40 per cent. oxygen, and is suitable for some illuminating and metallurgical purposes. The second dialyzer yields gas with 60, the third gives gas with 80 per cent. oxygen.

JAPANESE OIL OF PEPPERMINT AND MENTHOL CRYSTALS.

IN a circular issued by Messrs. Cocking & Co., of Yokohama, the following information is given concerning their oil of peppermint and menthol crystals. It will be found of interest as indicating the methods employed in that industry in Japan. Their production of oil now amounts to about 15,000 pounds annually.

The crude oil of peppermint is a product of the Japanese plant *Mentha arvensis, var. vulgatissima*, which is found both wild and cultivated in many parts of the country, particularly in the northern part of the island, where the soil and climate seem to be particularly congenial to its habits. It is there cultivated on a large scale, and generally three crops are obtained during the year. The first is cut about the middle of June, when the plant begins to blossom, and is about 1¼ feet high. The plants are then made into bundles and dried in the shade for about a month. A second crop is obtained in the early part of August; the third cutting takes place in September. The average yield in a fair season is about five tons of the dried plants per acre. The crude oil is obtained from these by steam distillation in apparatus of a rather primitive description, consisting of a large iron boiler, over which is constructed a tall wooden vessel, the condensation being brought about on the principle of the alembic. This operation is carried on by the growers under the superintendence of agents, and the product thus produced is the crude oil as it comes into the laboratory. The crude product consists primarily of two isomeric oils, viz., the oil of peppermint proper and the stearoptene, which is crystallized out. This latter is, in fact, the solid part of the oil, and is known in commerce under various names, such as "Peppermint Camphor," "Crystallized Oil of Peppermint," and lastly, the name given it by chemists, and by which we have introduced it, viz., *Menthol*. It will thus be seen that the Japanese plant produces two distinct substances, and these we will now describe separately.

The peppermint oil, after being separated from the menthol, is not a simple essential oil; but it is a well known fact among scientific chemists that it is chemically a complex substance, and a mixture of several bodies, but owing to the difficulty of separating these constituents, scientific researches have only resulted hitherto in fragmentary results. In our preparation of this oil we rectify it by fractional distillation, in order to eliminate as much as possible the remaining hydrocarbons and polymeric products, which would otherwise give rise to the peculiar smell in certain cases, which has hitherto been a cause of complaint by consumers of Japan oil. It is of a very pale, bright, clear yellow color and pleasant taste, being entirely free from the bitterness often found in the German and other oils. The specific gravity of the oil as above described varies between 0·890 to 0·930 at 10° C., and is generally about s.g. 904°, and no menthol crystals separate at temperature above the freezing point of water, but at 15° to 20° C. below freezing point it assumes a semi-solid condition like jelly, and thus remains perfectly unchanged at even lower temperatures. It also gives no diminution of volume when shaken with diluted glycerine, and is free from any distillation smell. If tested by distillation at 200° C., only a very slight proportion comes over, the greater part (95 per cent.) coming over at a temperature between 200° to 210° C., the mercurial column being wholly immersed in the vapor, and will be found upon analysis to contain very little or none of the polymeric products already referred to. When distilled at a temperature of 206° to 208° C., it yields the following mean results upon analysis, viz.: Carbon 77·52, hydrogen 12·29, oxygen 10·19 per cent., and in composition may be placed intermediate between the formulæ $C_{10}H_{18}O$ and $C_{10}H_{20}O$, and which analysis, therefore, may be taken as representing the oil.

Menthol is prepared of two qualities, the ordinary crystals and the recrystallized. Both these preparations are dry, and free from contaminated oil. Like the peppermint oil, it is also, chemically speaking, a very complex substance, and has received a considerable amount of attention from scientific chemists.

The purified article is in beautifully large trimetric needle crystals, which Messrs. Cocking & Co. sometimes succeed in producing six inches in length. These crystals, after being entirely freed from oily contamination, melt in a capillary tube at 39° C., and solidify again when the temperature falls to 27° C. Its density at 20° C. is 0·8876 as compared with water at the same temperature. It boils at 211° to 212° C. without decomposition, and when distilled at this temperature leaves no perceptible amount of residue. It is readily soluble in alcohol, ether, chloroform, carbon disulphide, and most of the essential oils. Many strong acids, both mineral and organic, freely dissolve menthol without change at ordinary temperatures, but reactions set in when heat is applied; in this way several compound ethers are formed, such as acetate and butyrate of menthol, which are colorless mobile liquids. The latter is easily obtained by the action of strong butyric acid upon menthol as about 200° C., and rectifying the resulting liquid product. By the action of strong hydric nitrate an acid is obtained which is believed to be pyrotartaric acid. The compounds of alkaline metals with menthol are all very unstable bodies. Besides the above reactions of menthol, it has been resolved into several compounds, the principal derivative being *Menthone*, having a composition which agrees with the formula $C_{10}H_{18}O$. It is a colorless mobile liquid, neutral to all test paper, soluble in the same solvents as menthol itself, but insoluble in water. It boils at 204·3° C. (corrected) and its odor much resembles that of menthol. Menthone is not a homogeneous body, but a mixture of several hydrocarbons, among which probably may be terpene and cymene. The reactions of menthone show that it stands to menthol in a similar relation to that in which ordinary camphor of commerce stands to camphol. Another hydrocarbon of menthol is *Menthene*, with a composition of $C_{10}H_{18}$, which is also a colorless liquid similar to menthone, but with an odor resembling that of cymene, and of a peculiar refreshing taste. It is moderately soluble in ether and alcohol and more so in benzine, turpentine, and other essential oils, and it enters into combination with halogen acids when heated with strong solutions of such acids. The last derivative compound of menthol which we shall notice is the terpene hydrocarbon having the formula $C_{10}H_{16}$, being the next lower term to menthone. This was first isolated by Oppenheim from dibromide of menthene, and can also be prepared by the direct action of strong hydric iodide upon menthol.

REPORT ON THE ADULTERATION OF ESSENTIAL OILS.

THE Pennsylvania Pharmaceutical Association, through the chairman of its Committee on Adulterations, addressed to Messrs. Fritzsche Bros. a request for information concerning the adulteration of essential oils, and that firm has replied as follows:

"There is no doubt that many of the former adulterations of essential oils have of late been abated, as buyers usually grow more attentive to the examination of special lots, as well as for the reason that a higher pharmaceutical education has had a most salutary effect in that respect.

"Still, in the matter that the detection of sophistications grew more expert, the adulterators were also stimulated to more ingenious admixtures, as they likewise benefit by a superior education, which they apply to their nefarious business, so that at present experts meet with oils which they know to be sophisticated, but which require tedious experiments and analyses to determine the nature and qualities of the adulterations."

The following list of the chief adulterants of some of the principal oils is also given:

Oil of bitter almonds with oil of mirbane, and also inferior qualities from apricot and peach kernels.
Oil of amber with crude petroleum.
Oil of aniseed, the finer Russian quality with the Chinese oil of star anise.
Oil of bay with oils of pimento, cloves, and nutmeg.
Oil of bergamot, when high in price, with the cheaper oil of sweet orange.
Oil of cade with common tar.
Oil of cajeput with camphor, dissolved in oil of turpentine.
Oil of caraway with oil of the chaff.
Oil of cardamom with oil of cajeput and camphor.
Oil of cassia with fixed oils.
Oil of cedar with oil of turpentine.
Oil of Ceylon cinnamon with oil of cassia and oil of cinnamon leaves.
Oil of croton with cheaper fixed oils.
Oil of cubebs with oil of copaiba.
Oil of rose geranium with the cheaper oil of ginger grass.
Oil of hemlock with oil of turpentine.
Oil of juniper berries with that of the wood, and the latter with oil of turpentine.
Oil of lemon with alcohol and castor oil; also fixed oils.
Oil of neroli with petitgrain and bergamot.
Oil of orange with alcohol and fixed oils.
Oil of patchouly with oils of cedar wood, copaiba, and cubebs.
Oil of peppermint with oils of turpentine, pennyroyal, and arbor vitæ.
Oil of petitgrain with oils of sweet orange and bergamot.
Oil of rose with oils of citronella, cubebs, rose geranium, copaiba, and also with spermaceti.

Oil of rosemary flowers with oils of cheaper grades.
Oil of sassafras with kerosene and oil of turpentine.
Oil of sandalwood with balsam copaiba and oil of Florida cedar.
Oil of spearmint with oils of pennyroyal and turpentine.
Oil of thyme with oil of turpentine.
Oil of verbena with that of lemon grass.
Oil of wintergreen with those of turpentine, birch, and also alcohol.

The well-known adulterations of musk generally consist of dried blood, and also the same article exhausted with alcohol; while for civet the principal adulteration is stated as honey.—*Oil Paint and Drug Reporter.*

THE ALCOHOL HABIT.

By DR. WILLIAM B. CARPENTER.

ADDRESS SUNDAY AFTERNOON UPON THE PHYSIOLOGY OF ALCOHOLICS—EFFECT UPON THE BODY OF ALCOHOLIC STIMULANTS—CONSEQUENCES TO THE MIND—IMPORTANCE OF EARLY GOOD HABITS.

DR. WILLIAM B. CARPENTER, who has just finished his second course of lectures at the Lowell Institute, was the lecturer in the regular temperance course in Tremont Temple Sunday afternoon, Dec. 3. A very large audience gathered, says the *Boston Advertiser*, and many prominent temperance workers were upon the platform. Governor Long presided. The Governor's introduction of the distinguished speaker was brief and complimentary. Dr. Carpenter's address was as follows:

Mr. Chairman, Ladies and Gentlemen: The request which I had the honor to receive a week since to deliver an address upon a subject which has occupied my attention during my whole scientific life, was one which I did not feel at liberty to decline, for the issues of this question are so momentous that it has always been my belief that when any one has an opportunity to speak with any authority upon this subject, he should avail himself of that opportunity to bear his testimony in regard to it. Having been myself in the habit, for thirty years I may say, of giving a very considerable amount of attention to this question in all its relations—in its relations to the physiology of the human body, in its relation to the physiology of the human mind, and also in its relation to the science of toxicology, for I have for many years made a study of that science—I can believe that some words of mine may not be without their influence in a community in which I have been received with the most cordial greeting, and which has listened to my teaching on other subjects with a degree of attention which could not be but gratifying. Without further preface, then, I will proceed at once to the question, and the first point that I wish to bring before you is just this: Any one who is familiar with the action of poison upon the living animal body, and has made that a subject of special study, has not the smallest hesitation in saying that alcohol is a poison. There are any number of well-attested results of its administration experimentally upon animals, in which it is shown that it is a poison. Yet it may be thought by many of you that if it is a poison its action is very, very slow when taken in small, continued, repeated doses. I admit that freely. It is a very, very slow poison in the great majority of instances; but I do not regard its action as any less sure because it is slow. After very large experience, experience of our life-insurance companies, of our benefit societies—and I think you have similar institutions in this country, a sort of mutual insurance for working-men, for payment during sickness—the experience of all these is entirely in this direction, that life is shortened and disease induced, and the body, even, very materially injured by indulgence in alcoholic liquors.

Now the next point I would endeavor to impress upon you is this: We desire to grow up securing what the Romans call "*mens sana in corpore sano*"—a sound mind in a sound body. Now we are agreed that it is the mind that makes the man, and consequently, as your own Emerson says: "Mind rules the universe," and a sound mind is what the physiologist—I am not speaking of that relation of the higher and graver question connected with the mind and body—regards unquestionably as most intimately related to the soundness of the body. Now it is a fundamental principle on which the physiologist rests all his predictions as to the securing and maintaining this soundness of action, that the blood shall be well made and well aerated, that it shall be able to convey to every tissue in the body its prepared nourishment, and that it shall also be enabled to convey those two great streams so important to physical action, the white portion of the blood and the red particles bearing the oxygen which is an essential condition of the working of the muscular tissue. If we stop the supply of oxygenated blood to the brain, if we send badly oxygenated blood to the brain, if we stop the supply of oxygenated blood to the muscles, or send unoxygenated blood to the muscles, they fail to exert their full amount of power. There is need of a continual supply of pure oxygen and a continual renewal of the product of the action which has taken place. Brain and muscle, with every operation, cause the waste of some material, and it is only by the constant renewal of these waste products, what we call the effete matter, which has done its work, the ashes, so to speak, that we can keep up this soundness of mind in a sound body. Now, what is the great vehicle for all this? What? You all know that whatever be the nature of the food that we take into the stomach, it has to be acted on, in the first place, by a watery secretion of the coats of the stomach—the gastric juice. This water combines with a small quantity of a substance called pepsin, which has the power of setting up a kind of fermentation in the material of the food; and again it is combined with a small quantity of muriatic acid, which is only a solvent for the food. Many of you, I dare say, are quite well aware that we can make an artificial gastric juice which will imitate the action of the stomach, and, putting this into a bottle, and putting into it food, and shaking it up occasionally, and keeping it at the temperature of the body, we can produce a solution which is comparable with the solution in the stomach in the human body made of the food when digested. Now, it is pretty certain that the addition of alcohol in any appreciable quantity, diminishes the solvent power of the gastric fluid; that it interferes with the process of digestion instead of aiding it. The only possible way in which the alcoholic fluid can improve digestion is by a temporary increase in the quantity of fluid secreted in the manner which I shall presently describe to you, as you may know that alcohol affects the circulation. Any increase in a healthy body is always, I believe, followed by a subsequent diminution, and so we do not gain anything in the end. But that alcohol interferes with the process of digestion may be said to be a well-ascertained fact. The fluid which goes into circulation is that which makes blood. Blood is being made during the whole process of circulation. That making of the blood lies at the basis of the whole of the nutritive operation. A very important part of this making of the blood is the production, growth, and multiplication of what are called red particles of the blood, with which you all are no doubt familiar. Now the blood may be considered as consisting of the liquid in which the red particles flow and of those red particles. These have two functions. The white liquid carries the red particles, and is concerned in the respiratory process. Regarding the nutritive operation of the blood, the red particles are the carriers of the oxygen from the lungs to the various parts where it is needed, and as carriers of carbonic acid from the various parts to the lungs, to be robbed of it there. Thus it appears that the blood-stream consists of these two separate constituents, each of which has its own particular function. I do not say that there are not other agencies in the respiratory process, and others than the red particles in the nutritive; these are points not satisfactorily determined. No physiologist has any doubt at all that the stream of liquid bearing the red corpuscles is concerned in the respiratory process, and the corpuscles themselves are most active in the nutritive. In some of the lower marine organisms, there are two distinct systems of circulation—one of colorless blood and one of red blood.

The great mass of the blood consists of water, and anything else introduced is not only so much surplusage, but so much that is foreign. The introduction of alcohol into the blood can do nothing but mischief. It alters the normal, regular, healthy condition of the blood, and there is a point upon which my friend, Professor Richardson of London, who has paid great attention to this subject, has dwelt, namely, that it alters the healthy appearance of the red corpuscles. When they are seen under the microscope they seem irregular, and that indicates that they are not in a healthy condition, and particularly because they run together in circulation. If they run together, the surface which is exposed to the air is not as large, and this condition interferes with the rapidity of the oxygenation. The larger the surface, the greater the rapidity of the change. Anything which makes the red corpuscles run together, instead of swimming separately, as we all know they do, as we see them in the case of the blood of a frog, checks the rapidity of the aeration. Now, there is one thing which every school in the land should have; every scholar should be able to see these corpuscles as well as to hear them described. Naturally the red corpuscles run separately and freely. If a stream of carbonic acid be sent into a frog's foot which is under the microscope, it will cause the red corpuscles to run together in such a way as to make them join together and stop the circulation. Alcohol tends to do the same thing as this poisonous acid. So evil is caused by the introduction of even small quantities of this agent into the blood. It interferes with the normal respiratory process. Nothing is more important than the heart's action for the maintenance of this process. The respiratory action is greatly reduced in repose, and the heart's action is reduced also. We do not need at night to keep up the same circulation that is required for vigorous action during the day. In a healthy condition the wonderful harmony of the system proportions the respiration and the process of circulation to the needs of the time. We all know how, when we are walking briskly, the heart's action increases and the respiratory action increases. If the coat or dress is tight, there is a feeling of restriction, and on going up-hill this restriction is strongly felt.

This action is controlled by a nervous system, of whose functions we have only come in the last few years to have any conception—the *vaso-motor* system, which regulates the caliber of the blood-vessels. It has a great influence on the circulation. The blush of nervous agitation and bashfulness or the pallor of fear is due in the first place to the relaxation of the capillary vessels, causing an increase in the amount of blood to be sent into them in the case of the blush, and a contraction of those vessels and a diminution of the amount of blood in case of pallor. The vaso-motor system has its function in sending to every part of the body the amount of blood which its condition may need. Thus the blood comes to the salivary glands in a very small quantity in the ordinary periods of rest; but when they are put in action, the vaso-motor system immediately relaxes the great trunks that convey blood to them, and a much larger quantity of blood is sent in consequence, while the blood is not sent regularly to any one part. Where there is need of blood, there this system sends it. It is so in the case of muscular action. When a muscle is at rest, the blood sent to it is small in quantity and it returns very little changed; it is almost arterial in its character. But once put the muscle into action and a much larger quantity is sent, and the blood comes back in a highly venous state, showing that it has lost a quantity of oxygen and received a quantity of carbonic acid. All this wonderful adjustment takes place of itself in a healthy body, and anything made to derange this will cause harm. Now it is the result of many observations that it has been shown that the introduction of alcohol does derange the vaso-motor system. As this system also controls the action of the heart, its action is disturbed by the introduction of alcohol. A change is caused also in the relaxation of the capillary vessels. They become filled with bood, especially in the nervous system and in the skin. This causes one to feel that warmth and exhilaration which is the first effect of the introduction of these disturbing agencies. It is this exhilaration and warmth that are appealed to as evidence that drink does us good. Well, what are the facts? The fresh glow is simply the result of relaxation of the capillary vessels of the skin, allowing a larger quantity of blood to come to the surface, and thus give the feeling of superficial warmth. But if a larger amount of blood comes to the surface it robs the parts within, and the feeling of genial warmth gives way to a genuine depression, especially when we are exposed to severe cold. The temporary exhilaration of the nervous system is followed by a corresponding depression. Hence a person feels sick and sore the next morning after taking alcoholic stimulant.

That there is any advantage in taking alcohol is a myth altogether exploded. I ventured many years ago to maintain this on the basis of testimony of the best kind which I had obtained. My friend Professor Richardson said then that I was in advance of my time. We had no scientific basis except experience. My first illustration was obtained through Professor Richardson, and comes from a medical officer in the naval service who was associated with Sir John Franklin in Arctic exploration. It was the conclusion of Dr. John Richardson—who was the officer meant—that the use of alcoholics did much more harm than good; that it was better to burn the alcohol in a lamp and heat tea or some other liquid with it and drink it, and so get the effect of the heat, then to put the alcohol in the stomach, for what heat they got from one was a gain, while the other, being a stimulant, was followed by a depression which made the cold seem only more severe. Another account has been given by one who passed the winter with a party in the north of America, as near the borders of the sea as they could reach. They were well supplied with food, and lived in a log-house which had been built for them by our Canadian Company. He made it a strict condition that they should go out upon strictly total abstinence principles. He would not have any spirit at all. As a party, their work through the winter was to make a series of magnetic observations, and it was necessary that the magnetic observatory should be at a short distance from the house in the order to avoid the local attraction of iron. The officer said he was accustomed to go out at night from the house to the magnetic observatory, as it were, to go across the street. There he would make an observation and return without putting on his great coat. I asked him how cold was the temperature to which he exposed himself. He said that the temperature in the log-house was about fifty degrees above zero, and that outside it would sometimes be about fifty below zero. There was a change of a hundred degrees which he found he was able to endure for a quarter of an hour without putting on his great coat. That will show the kind of evidence which I proceeded upon. Many of our Arctic voyagers have given me the same experience. Sir Joseph Hooker, who served with Captain James Ross in his Antarctic expedition about forty years ago, has given evidence to me of nearly the same kind. We have found the *rationale* of the action in the stomach to be an increase of the gastric juice. But why should it be increased in a healthy body? A healthy body secretes sufficient for its purpose. Why should we provoke it to a result not required for digestive action? We do this at the expense of subsequent loss. We lose afterward all that we seem to gain. Now, what does muscular action depend upon? It is upon the burning of a certain amount of sugar in the muscles, and the amount burned is the measure of the stimulus to muscular contraction. Whether we experiment by taking the muscles of a frog freshly killed, or whether we get our knowledge in any other way, it comes to this, that muscle-sugar is burned up to produce what may be a fair measure for the amount of heat; the muscular force is an exact equivalent of the heat in the carbon and hydrogen consumed. So the heat produced in a muscle, just like that in a steam-engine, depends upon the amount of fuel. The muscular action may be increased by increasing the stimulus. But the muscular action is accompanied by chemical change. The utmost that alcoholic stimulants can do is to give us a spurt, just as boat-racers spurt when one is behind the other. But just afterward there is an increased sensation of fatigue. Any increase of muscular stimulus is simply an anticipation of the amount of strength which can be used, like drawing our pay before it is due. It has to be made up afterward. When we work there is a feeling of fatigue, which I believe represents the amount of effete matter in the blood which has to be got rid of.

I now come to the last of these points—that alcohol interferes with the elimination, with the getting out of the body what I call the ash and smoke—the result of the chemical changes. There can be no question that the presence of alcohol in the blood does interfere with this process, that there is a tendency to the accumulation of waste matter, which is the very worst in both recovery of vigor by rest, and again, is the very worst in this important particular—that while this effete matter is in the blood, we are in a condition which renders us more susceptible to any morbid influence whatever. I shall give some remarkable instances of this. I have been accustomed to deal with leading cases which seem to remove any opportunity for dispute or hesitation as to their application. I will give you a leading case, which made a strong impression upon me. When I was a youth I visited the great factory in Birmingham of Boulton & Watts, who were great steam-engine makers. The factory was then, and a long time after, very celebrated. At that time they were making coin, and Boulton & Watts' pennies are now regarded with much curiosity by coin collectors. This was perhaps fifty years ago or more. They were then coining for a number of foreign governments. I was taken into the workshop, where there was a man whom I remember as the most herculean person, not so much in height as in breadth of chest, that I ever saw. He was engaged in welding steel dies into iron blocks which they required for casting, and it needed great skill and great muscular power. This man was celebrated in the works as the only man who could really do this work. The hammer was very heavy, and he wielded it with masterly power and precision. If the blocks were not thoroughly hammered and welded, they would be liable to separate under the pressure of coinage.

It was on a hot summer's day. He was naked to the waist and wet with extreme perspiration. When he came to a pause in his work, I asked him what he drank. He pointed to a bunch of beer-bottles and said: "When I am thirsty, I pick up and empty one of those. I take about thirty or forty bottles in a day." This brings up the point that this perspiration which we think requires to be checked is from the blood, and can be restored by drinking water. Why should we take alcohol? This perspiration prevents the heat of the body from rising too high. When a man is drawing moisture from his body by perspiration the temperature is reduced, and he is enabled to continue his work. The heat is thus very much below what it would be otherwise, and he has only to take a draught of water from time to time to maintain the perspiration. The Turkish bath is largely employed as a remedial measure. I have remained in such a bath half an hour, with the temperature at 160 or 180 degrees, being in a perspiration, and drinking a glass of water occasionally for recruiting the supply. The strengthening and invigorating effect of this bath is admitted by every medical man in a particular kind of cases—not that it should be too often taken. Perspiration in itself is not weakening, as is sometimes thought because persons perspire in disease. But in this case it is not the perspiration which is weakening, but it is induced by the exhaustion caused by the disease. [At this point a listener in front of the platform put in a question, but Dr. Carpenter said that he preferred not to answer any questions while he was delivering his lecture.] With regard to the sustaining of muscular force, all physiologists agree that it is food that enables the muscles to be nourished, and the oxygen enables the muscles to be put into action. I will give you a leading case. A captain of a vessel returning from Australia found that she sprang a leak soon after leaving Sydney, and the course did not allow him to put in at Cape of Good Hope. Nothing could be done but to endeavor to keep the ship afloat all the way home. At first he issued to the men their regular allowance of grog, but he soon found that they were running down in strength. Labor at the pumps so constantly fatigued them extremely. At the end of the watch they would drink and turn in. At the end of four hours they would awake unrefreshed. He saw that this must be changed. He stopped the grog, and ordered that at the end of the watch each man should be given a mess of cocoa and sugar with his meat. This changed matters very much. They took this food be-

fore they turned in, and this sugared cocoa renewed the material of their muscles and put them into a condition in which they could sleep soundly and awake refreshed. He assured me that he brought his men into harbor, after all that severe work, in as high a condition as ever a crew came home. [Dr. Carpenter related an instance which came under his notice in the West Indies, in which a frightful mortality among Europeans was caused by the use of alcoholic drinks in very hot weather, and also told of a regiment which was composed of temperance and total abstinence men. The temperance men were in much better health than the drinking men in other regiments, and the total abstinence men had even a decidedly better record than the temperance men. The remainder of the lecture is summarized below.]

Now, if that be the testimony of science with regard to the health of the body, how much stronger even is the testimony of science with regard to the mind. There is no doubt that the use of alcohol tends to the fatty degeneration of the tissues in the muscles, and particularly in the walls of the arteries and in the muscles of the heart. I come now to the last point—the healthy condition of the brain in its relation to the mind. Many of you are aware that I have been lately delivering some lectures on the automatonism of the human body, and endeavoring to show that the human body may be regarded as an automaton, as a piece of mechanism having certain powers within itself, and that the will has the power of setting this automaton to do its work. It is the direct and immediate tendency of alcoholic indulgence to weaken, and finally destroy the faculty of automatonism. The tendencies toward any particular action are intensified. If a man is quarrelsome, when intoxicated he is more quarrelsome; if good-natured, then he is more good-natured when intoxicated. A merchant told me that he found people were anxious to trade with him just after his dinner, and asked me what he should do. I advised him to stop drinking at dinner and not let his customers take advantage of his unusual good nature. I have endeavored, in my other lectures, to show the importance of the formation of good habits, for if they are formed early one will get a strength which he will otherwise have to work hard to attain. Every time we gain a victory we get strength for the next struggle. My only advice to the young here is to keep away from temptations, and to fix their habits with such a determination as shall keep them out of temptation. That is my great point. Every victory gained is so much for good in the future. Some go on, saying that they can pull up at any time when there is danger, but when that time comes, to pull up is found very difficult or impossible. You may say that there is no danger yet. There is an old adage, *obsta principiis*—oppose the beginnings, for no one who makes a beginning can tell what the end will be. Many of you have doubtless made up your minds; perhaps some of you have not. But in this matter my advice is: Begin at once, turn to the right, and keep straight on.

BRAIN HEALTH.

A LECTURE before the Edinburgh Health Society was lately delivered by Dr. J. Batty Tuke, whose subject was "The Establishment and Maintenance of Brain Health." Dr. Tuke said he held it to be a well-ascertained physiological fact that the brain cells were organs which could be acted on for good or for evil, and that they were directly subject to the laws of health. Turning to the title of his lecture, Dr. Tuke remarked that it involved consideration of the most intricate and difficult social questions. It might be said in passing that, as a nation, we had decided to adopt a system of education which was in itself the greatest brain tonic at our command—a remedy which, if not altogether a specific, must strike deeply at one great cause of crime, misery, and degradation. Especially in our great cities there was a considerable class, the members of which might be termed moral idiots. A child brought up, or rather dragged up, in a cellar; whose parents were thieves by profession; whose companions were equally degraded; who was surrounded from his earliest days by scenes of debauchery and wickedness, must almost inevitably fail to develop a moral sense. Right was wrong to him, and wrong was right. Strictly speaking, this was his moral sense.

Some of them might feel at times inclined to grumble at the expense and working of the Education Act; but the grumble would cease if they reflected that they, as a nation, were doing their very best to remove a serious opprobrium from society. The Compulsory Education Act was something like the Compulsory Vaccination Act. Society had determined, in the one case, to apply a preventive to the spread of a serious and dangerous bodily disease; and in the latter, to a grave and serious moral disease. As a community, they in Edinburgh might congratulate themselves that they had done, and were doing, their best to clear the city of the noisome dens in which the residuum of society was born and bred.

In speaking of the influences which act for good or evil on the brain, Dr. Tuke alluded first to those over which the individual had no control; and, secondly, to those over which every man and woman could exercise control. The influences over which the individual had no control were those connected with his antecedents and up-bringing. A man might be handicapped in life by the mistakes or faults of his ancestors; and, different from the racehorse, he had to carry weight in the race of life according to his imperfections, not according to his advantages. There was a pretty general consensus of opinion that consanguineous marriages were on the whole to be deprecated. If they taxed their memories, and tried to remember how many perfectly healthy families they had known—families without a history of consumption, gout, rheumatism, affections of the nervous system, etc.—he feared the number they could estimate would be very small; and if they took into account the tendency of such diseases to become intensified in the children of cousins, he thought they would agree with him that consanguineous marriages involved a risk which it was not well to incur.

Alluding next to a question which was often put him by anxious parents, whether it was advisable to allow their children to marry into families in which nervous disease was known to exist, he remarked that, of course, as an abstract proposition, there was but one answer to the question—that it was not advisable; but while he did not advocate marriage under such conditions, he expressed the opinion that there was not much more, if any, reason for avoiding a family in which there was a history of nervous instability than there was for avoiding families in which other forms of hereditary disease existed.

Passing to consider the practical questions connected with the rearing of the infant and child, he said every child's future history depended on the food it got and on its surroundings. Much depended on the mother; if healthy, she should suckle her child, but not for too long. He had met with many cases in which the sole ascertainable cause of nervous symptoms in young children was their being too long suckled. But the mother herself must be well fed, and this brought him to the consideration of another question. In some respects he believed the food of the working classes in Scotland was improved, partly because wages were higher, partly because in the new workmen's houses the means of cooking were better, and partly because new articles of diet had been introduced into the market. But he also believed that it had become deteriorated in a very important item—porridge and milk—for which had been substituted a much less nutritious, and in itself a somewhat deleterious, article of diet—tea and bread. The physiologist would tell them that porridge and milk was a "typical" food, that was, that it contained all the necessary constituents of food in the most perfect proportions. He had nothing to say against the staff of life so long as it was sound in quality and well fired, except that it was not such a typical food stuff as oatmeal, and, weight for weight, did not possess an equal power of nutrition as porridge. It was the constant use of tea that he would most strongly deprecate. He hoped his teetotal friends would not be very angry with him if he said that it was quite open to argument whether the teapot or the whisky bottle exercised the more baneful effects on the public constitution. He did not think the question had ever been fairly worked out. He advised all working men, whether they worked in the workshop, in the office, or in the study, to feed themselves, their wives, and their children, at least once a day on the most perfect form of food which God had given them—porridge and milk.

The next subject which naturally suggested itself as exercising an important influence on the child's brain cells was education. In Edinburgh philanthropy had taken the direction of providing institutions for the education of orphans and of the children of poor people—noble and great institutions which had doubtless effected much good where their function had been exercised for their proper objects. But it was more than doubtful whether they exercised a beneficial influence, if they, in any instance, took a child from its home and the Board School. He held that a man must be very poor indeed to be justified in giving up the care of his child, and that he who could maintain even a very moderately comfortable home outraged the laws of society and of health in debarring his child from its educational influence. To send a child away from the family influence into an atmosphere of necessarily strict discipline and routine should be the last resource of misfortune. The life of a child so placed was artificial, its individuality was endangered, and its experience circumscribed. With every respect for the management of these institutions, he would much rather see a child of his less well dressed, less well fed, living early into real life, his brain cells absorbing real experience and becoming educated by normal vicissitudes, than see him the best boy in the best hospital. He was speaking as a physician and a physiologist when he advised them to avoid the temptation, should it be presented to them, of sending their children to any institution when by any sacrifice they could keep them at home. Of course, a child had to encounter greater dangers at home than when shut up in a monastic institution. They were overworked, and overworked themselves, at school. One of the great causes of overstrain in early youth was the vicious system of offering prizes for competition. It deflected the mind of the child from the main aim and object of its study, and often defeated the object which it was hoped to obtain. The youthful mind must not be pressed too far in the direction of abstract fact and theories. Our whole educational system was running somewhat wild in this direction, and the child's brain did not get time to assimilate the food it got. A sort of brain dyspepsia or indigestion set in.

His experience might be exceptional, but it tended toward the opinion that the rising generation was not so well acquainted with the standard literature of our own country as boys and girls were twenty-five or thirty years ago. He dared say its knowledge of the hard facts of history was more exact, the rules of arithmetic might be more thoroughly understood, but he doubted very much whether "Robinson Crusoe," the poems of Burns, the "Pilgrim's Progress," Sir Walter Scott's glorious novels in prose and verse, Prescott's "Conquest of Mexico and Peru," and such like educational influences were as much at work as they used to be. Careful reading of such standard books helped the boy's and girl's brain to assimilate the tougher food it received at school, and introduced a digestive power which helped to diffuse the aliment throughout the whole mental system.

Having pointed out the necessity of teachers knowing how to administer intellectual aliment carefully and thoughtfully, and how brain health suffered nowadays, if there was truth in the statement that the pupil was being made for the school, not the school for the pupil, Dr. Tuke remarked that a great deal had been said and written of late about the overworking of girls and young women in schools and colleges, and his friend, Dr. Clouston, had come forward as the champion of health and ignorance for women. He could not help thinking that Dr. Clouston had overstated the position of matters; that he had based his opinions more on the observation of isolated cases than on the general condition of highly-educated women; that he had mistaken the wail of the one for the murmer of the many. No doubt, a certain number of young women suffered and broke down while studying, but this did not necessarily imply that study was the cause of the breakdown. Idleness and ignorance were much more prolific causes of disease among women than overwork. They were the main producers of hysteria, and all sorts of vaporish complaints, of many ills and evils, and of inanity, if not of insanity. As a matter of fact, it was not an easy thing to overtask the energies of the brain by work. It was not work, but worry, that killed the brain. The latter, he feared, must be ever with us all. The most highly educated and hard-working women whom he had the honor of knowing were eminently healthy. Perhaps this might be the "survival of the fittest;" but even granting that it was so, the more women worked the more fit women they would have. But breakdown from overstrain did occasionally take place, and the first really important symptom was sleeplessness; when that set in; there was cause for alarm. Loss of sleep was brought about thus: When the brain was being actively exercised, there was an increase of blood in its vessels; this was spoken of as "functional hyperæmia." If they continued the exercise of the brain powers too long, there was a tendency for the blood to remain in too great quantity from the cells becoming exhausted and not being able to control the vessels. In sleep the amount of blood was diminished, and sleep could not be procured if this functional hyperæmia persisted. In the absence of sleep, the cells could not recover themselves, and their activity became impaired. Headache, loss of appetite, and general listlessness followed; then changes in the character of the blood; and the trains of symptoms so ably described by Dr. Clouston. As soon as a child or young person developed continuous headache, work should be discontinued at once.

In conclusion, Dr. Tuke remarked that most men working in the same department of medicine as he did recognized that if there was a hope of diminishing the amount of brain-disease, it was to be effected by preventive medicine, and he had therefore directed their attention especially to the transgressions of the father rather than to those of the son.

A LESSON IN COMPARATIVE ZOÖLOGY.

HUBBARD W. MITCHELL, M.D.

HAVING entered the wide field of zoölogy, we see before us a multitude of animals of different forms, sizes, colors, and habits. At first view there does not seem to be the least similarity between any two of them. All appear totally different and distinct.

Here the naturalist and the comparative anatomist step in, and begin to study this great mass of animal life, and see upon what plan, if any, it is formed.

He begins by comparison. He compares one form with another, and sees if any two or more animals have any qualities in common. If so, he assigns them to some order and species, and in this way he simplifies their study.

Let us apply this principle of comparison in practice. Suppose we see together, for instance, the following:

A Pig, Tapir, Peccary, Elephant.....	1
A Lion, Tiger, Panther, Cat.....	2
A Dog, Wolf, Fox, Jackal.....	3
A Goat, Deer, Ox, Sheep, Camel	4
A Horse, Ass, Zebra	5

How shall we compare them, in order to find feature com mon to any two or more of them?

Perhaps the feature that strikes us first would be the horns in the ox and the deer. Can we associate these with any of the others?

If we examine the teeth of all the animals in the first, second, and third lines, except the elephant, we shall find them sharp and cutting, with long canine or prehensile teeth, admirably adapted for seizing and holding living prey, and for cutting and tearing it. We should, therefore, call these animals carnivorous. If we examined the teeth of the animals in the fourth and fifth lines, we shall see that they have large flat surfaces well adapted to chewing and grinding, and as they live on vegetable substances, we shall call these animals herbivorous.

Comparing still further, we find that in the horse and the ox, both herbivoræ, the horse has incisor teeth in the upper and the lower jaw, while in the ox there are incisors in the lower jaw only, and this arrangement of teeth has a direct relation to the different structures of the stomach in the two animals, the ox having a complicated stomach with four pouches adapted to a mode of digestion by which the food is prepared for a second mode of mastication. This order of animals, those in the fourth line, are called ruminants.

The animals in the fifth line have simple stomachs, and do not ruminate.

If we again compare the ox, this time with the deer, we shall find that while both are herbivorous ruminants, and both have horns, in the ox the horn is hollow and remains firmly attached to the animal's head through life; in the deer it is solid and is shed every year.

Upon looking further we find that the pig, tapir, and peccary, carnivorous animals, have a cloven foot like the herbivorous animals in the fourth line, and those last, again, are different from the herbivorous animals in the fifth line, which have a solid hoof or foot.

These comparative studies will enable us to classify animals into different orders and species.

Naturalists tell us that certain animals sprang from a common stock, and the differences between them are the results of modifications of structure gradually occurring during long periods of time. Thus the pig has a stout, rounded body and a mobile nose. The peccary is a step higher. Then in the tapir the body is about the same, but the nose is decidedly more developed. The rhinoceros comes in next with the same form of body, and his nose modified and turned upward into one or two horns, and lastly the elephant, with his long mobile nose or trunk, is the highest expression of this common stock.

The order Felidæ, or cats, are almost precisely alike, the differences being chiefly of size, color, and growth of hair. The lion, tiger, panther, leopard, puma, and cat certainly sprang from a common stock, the domestic cat, perhaps, having the highest development, from the fact of its ability to rotate the radius upon the ulna, a motion the larger cats do not have. We see the grace of this motion when our cats play with a mouse or a ball of yarn.

The same fact is seen in the Canidæ, or dogs. They came from a common stock also. The wolf, jackal, dog, and fox are of the same species, and have the same structure.

In the graminivorous ruminants, the origin from a common stock is apparent. The sheep, with its woolly coat and curved horn, undergoes a slight modification, and we have the goat, also with a curved horn and woolly hair. A further development gives us the deer, and further still the ox. Then comes the camel, and lastly the camelopard, or giraffe.

As an interesting instance of the structure of animals conforming to their modes of life, the giraffe may be mentioned. This animal feeds upon the foliage of trees. Upon his head he has tufted sensitive horns that he may *feel* his food as he passes along. His elongated neck enables him to reach it easily, and in order that he may be on the lookout for his enemies—the crouching lion being his most dreaded enemy—while his head is so high above the ground, his eyes are set so that he can see above, below, forward or behind without moving his head.

The complicated digestive apparatus of ruminants has some relation to their methods of escape from danger. As their food consists principally of vegetable substances, little nutritious and demanded in large quantities, and as they are in turn food for the ferocious carnivorous animals, their only means of safety is in flight, while mastication is a work of time.

They are, therefore, obliged to graze rapidly, fill their large stomach reservoir with unchewed food, and then retire to a place of safety, where they can remasticate it at leisure.

The horse, ass, zebra, and other animals of this order sprang also from a common stock.

We have now seen that by comparing animals with each other we are able to classify them into orders and species, each order and species having some distinctive character entitling them to a fixed and permanent place in zoological classes.

If, now, we examine all the forms of animal life on the

carto—the fauna, or the animal kingdom—we shall find that they can be comprised under four great heads—namely, vertebrates, articulates, molluska, radiates.

It is with the first of these only that this paper will deal.

As we saw that animals were classified under several heads by examining them externally and internally to a limited extent, and this classification gave us carnivora, herbivora, etc., so now, if we examine this immense order of vertebrates by the study of their bony framework, or osteology, we shall find that all, from an eel up to man, are constructed upon one single plan.

Beginning with man and descending in the scale, we will briefly examine this bony framework, or skeleton, and see what this plan is upon which a vast part of the animal world has been constructed.

First we find a skull, rounded in shape, hollow, having apertures for the eyes, mouth, etc., jaws set with teeth, and articulated upon the first of a series of bones, or vertebræ. These vertebræ, joined together by ligaments so as to form a continuous column, or backbone, mark the distinctive features of the whole order—viz., vertebrates.

From the upper part of this spinal column are given off twelve pairs of ribs, which, nearly meeting in front, form a bony cage containing the heart and lungs.

The upper extremities are formed by a scapula and a clavicle, a humerus, radius, ulna, carpus, metacarpus, and phalanges.

At the lower end of the spinal column is the pelvis, from which is given off the femur, the tibia and fibula, the tarsus, metatarsus, and phalanges to form the lower extremities.

This briefly is man.

In the Simidæ, or monkeys, the facial angle is a little greater, the humerus, the radius, and ulna a little longer, the tarsus slightly modified, and in some species the vertebræ are extended into a tail. These are monkeys, modified a little from man.

In the Felidæ and the Canidæ, the facial angle is still greater, the teeth sharp and cutting, with well developed canines, the upright position is changed to a horizontal posture, the upper extremities are now fore limbs, bones modified in shape, species mostly digitigrade. The bears all plantigrade.

General plan same as man.

In the remaining members of the carnivoræ, as the sea lion, seal, and walrus, the fore limbs are modified into paddles, while the hind limbs are less developed. In the walrus the lower incisors and canines are absent, while the upper incisors are elongated into tusks.

General plan same as man.

In the bovidæ, beginning with the camels and running through the llama, giraffe, ox, bison, yak, goat, zebu, gazelle, gemsbok, sheep, antelope, and deer, we have an elongated skull, modified bones of the fore and hind limbs, and a modification also of the carpus and metacarpus, the tarsus and metatarsus, whereby the foot is cloven, owing to consolidation of some of these bones. In some of the members of this order we have the horn, either deciduous or permanent, and in all the cauda. In some, also, we have a longer scapular and longer spinous processes. This affords greater attachments to the nuchal ligaments and muscles for those animals with heavy heads and horns. In the giraffe this is especially noticeable. The shoulders are so high that it makes the fore legs seem higher than the hind legs. This is due to the lengthened scapula and spinous processes. The heads of the femur and humerus are on the same level.

In all other respects, the general plan is the same as man.

In the cetacea, as the porpoise, dolphin, and whale, the skeleton is the same, except the hind limbs are modified into complete or rudimentary fins.

In the extensive orders of insectivora, rodentia, edentata and marsupials, the general plan is that of the higher animals and of man, modified to meet the requirements of its mode of life.

In the enormous class of aves, or birds, beginning with the robin and ending with the penguin, we have the elongated skull ending in a beak or bill, light porous bones, an extensive sternum, clavicles united to support the wings, various modifications of the humerus, radius, ulna, and the carpus, metacarpus, and the phalanges, as in the bats, etc.

In all the species of birds, the general plan is the same as man.

The same is true of the class Reptilia and Amphibia. In some of the snakes the legs are rudimentary, in others the ribs serve as legs. In the sharks the fins take the place of the fore and hind limbs.

In the class Pisces, or fishes, through the whole series down to the eel we have the skull, vertebræ, and ribs, and the bones of the fore and hind limbs are more or less perfectly represented by the fins. The pelvis in fishes is rudimentary, or wanting.

This brief sketch of the Vertebrata, from man to the lowly eel, shows that the whole sub-kingdom is formed upon a single plan, and that any variations are but simple modifications designed to meet some special requirement. The study of osteology shows us that in this long line of animals—the Vertebrates—the distinctive feature is the spinal column, and it is astonishing, as well as interesting, to observe how little difference there really is between the backbones of any two members of the whole series. The chief differences are in the structure of the head and limbs.

If we compare the anterior limbs of some of the lower animals with the arms of man, we shall see that bone for bone is present, from the humerus to the phalanges. For instance, take the anterior limb of, say, an ape, a bat, a dog, a mole, a deer, a whale, a seal, a tortoise, a fish, or a bird. In each we can distinctly trace the humerus, the radius, and ulna, the small bones of the carpus and the metacarpus, and the phalanges.

The differences of shape in each animal are simply modifications of the same bone to adapt it to its individual mode of life.

The intelligence of animals, no doubt, resides in the brain, and it is believed that the amount of the reasoning power, or faculty, is in some way proportioned to the quantity of *gray matter* of the brain.

In connection with the reasoning power of animals, depending on brain action, may be mentioned a provision of nature for their safety, which—although it has nothing to do with reason—acts in connection with it.

This is the *mimicry* of animals, or the adaptation of the color of an animal to that of surrounding objects in its native wilds.

Nature excites our wonder by her wisdom of this curious and interesting provision.

Thus the tiger, so beautifully decorated with black stripes upon a ground of reddish-yellow fur, tending to white below, living in the long jungle grass of Southern Asia, with the color of which its stripes so closely assimilate; it is impossible for an unpracticed eye to discern it, even at a short distance. This mimicry not only protects the animal's safety, but enables it to steal unseen upon its unsuspecting prey.

The uniform dun color of the puma gives it a mimicry for its safety and attack, while crouching upon the branches of trees.

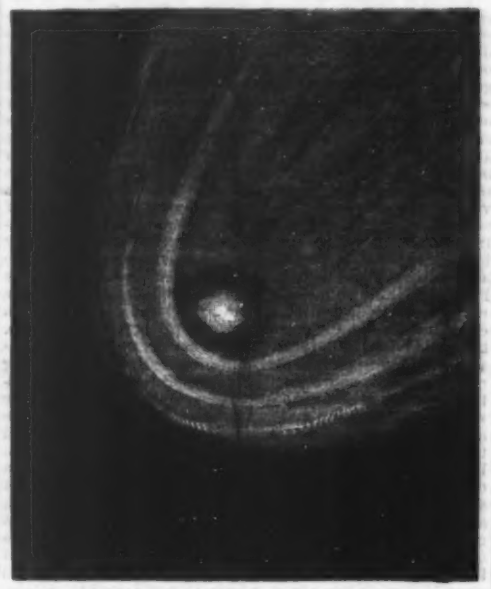
The dark circular spots upon the skin of the leopard give it a mimicry that utterly deceives, as it conceals itself among the leaves of bushes and trees.

The giraffe has, perhaps, the most astonishing mimicry of any animal. Inhabiting as it does the forests of Africa, and feeding upon the boughs of trees, its great size makes it a most conspicuous object. Its most dreaded enemies are the stealthy lion and man. In the regions it most frequents are many dead and blasted trunks of trees, and its mimicry is such that the most practiced eye has failed to distinguish a tree trunk from the giraffe, or a giraffe from a tree trunk.

Reliable accounts have reached us where lions have gazed long and earnestly at a motionless giraffe, and being in doubt whether it was a tree or not, have actually turned and skulked away.—*Journal of Comparative Medicine and Surgery.*

THE COMET'S HEAD.

WE have received from M. Bulard, of Algiers, a sketch of the head as seen in a powerful telescope, exhibiting the



THE HEAD OF THE COMET

system of envelopes rising from the nucleus, which has characterized several recent bright comets (see Fig.)—*Nature.*

A THEORY OF SOLAR SPOTS.

THE ear is affected by sound only through a certain range of vibrations in the atmosphere. "Our unconsciousness is no proof of the absence of sound. There are, doubtless, sounds in nature of which we have no conception."

The eye is affected by light only through a certain range of vibrations in ether. Is it not probable (it is surely possible) that there may be light or color which we are unable to see?

During the process of heating an iron, we may observe that the pulsations of ether do not affect the eye until they have attained a certain rapidity and intensity. Tyndall has shown that the effect of raising the temperature of a body is both to add quicker vibrations and to augment the intensity of those which already exist. Suppose the temperature of the iron to be constantly increased; a point would be finally reached beyond which the pulsations would cease to affect the eye, having become too rapid or too intense.

That the temperature of any part of the photosphere should fall below that of the surrounding regions is more unlikely than that some portions should become more highly heated than the adjacent parts, for conduction would preserve an even temperature throughout the sun, were it not for radiation. The descent of a comet, however, or downfall of a vast meteor, or body of meteors, moving with the terrible speed with which the sun would attract such bodies, would, according to the mechanical equivalent of heat, increase the temperature of the locality where it struck to an enormous degree. Perhaps regions in this way so fiercely pelted become so highly heated as to put forth ethereal vibrations which do not affect the eye as light; thus we see them as black spots, or rather, we do not see those regions at all. Moreover, since sun spots are said to be cooler than other parts of the solar surface, it may be concluded that the ethereal pulsations have also ceased, in part, to affect us as heat.

We know that electricity travels much faster than light, and if we accept the theory that this force, like light, is vibrations in ether, we may explain the relations between sun spots and electrical commotions on this earth by supposing that the spots radiate vibrations, which do not affect the senses as light (and but slightly as heat), but which produce electricity.

The fact that any increase in the number of solar spots increases the number of auroræ is now undeniably established. A great aurora causes a disturbance of the magnetic needle as well as producing great confusion among telegraphic systems.

Solar spots appear principally in two belts, parallel to the sun's equator. Following the general structure of the solar system, we see that most bodies which would strike the sun would be found revolving in orbits not very greatly inclined to the sun's equator.

Allowing that spots are produced by the falling of bodies into the sun, we can easily see that the eleven year period can be caused by the revolution about the sun of some great body of meteors which in a greatly elongated orbit revolves once in eleven years.

A CATALOGUE containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50, stitched in paper, or $3.50, bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
261 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ENGINEERING AND MECHANICS.—Revolution in Coal Hauling—The Finley method as developed at the Franklin collieries... 5841
The Fastest Trains in Europe and America. By A. L. ROTCH. The fast trains between Jersey City and Philadelphia.—Boston and New York.—New York and Albany.—Fast trains on European roads.—Italy.—France.—Germany.—England..... 5841
Chicago Cable Roads. By D. J. MILLER.—3 figures.—Side elevation of grip and grip car.—Section of track at curve.—Plan of curves and crossing..... 5850
Improved Sizing Machine.—1 figure..... 5851
The Panama Canal.—Map of the Isthmus of Panama showing the line of the great canal.—Plans of the ports of Panama and Colon.. 5852
The Moving of Large Masses.—7 figures.—Gin, with pulleys and windlass, used in handling the pedestal for the statue of Peter the Great in St. Petersburg.—Arrangement of the levers and capstans.—Details of the grooves.—Moving the rock overland.—Carriage of the rock by sea.—Jack screw..... 5853
Apparatus for Descending into Mines.—1 figure..... 5854
A Doubling Arrangement for flax..... 5854
New Method of Guiding the Tool in an Oval Lathe.—2 figures.. 5855
Paupier's Bagging Scales.—1 figure..... 5855
Machine for Weighing and Classifying Zincs.—1 figure..... 5855

II. TECHNOLOGY AND CHEMISTRY.—A New Developer for Gelatine Plates. By M. CHARDON..... 5855
Emulsion for Opal Printing..... 5860
New Sewage Process..... 5860
A Convenient and Delicate Test for Albumen..... 5860
Apparatus for the Production of Oxygen by Dialysis of Atmospheric Air..... 5860
Japanese Oil of Peppermint and Menthol Crystals..... 5860
Report on the Adulteration of Essential Oils..... 5860

III. ELECTRICITY, LIGHT, HEAT, ETC.—A Problem in Atomic Physics. By Prof. J. TYNDALL..... 5845
Improved Form of Battery Cell.—1 figure..... 5845
Long Distance Speaking.—Obstacles to long range telephoning.—Induction.—Leakage.—Speaking without wires.—1 figure..... 5856
Domestic Electricity.—5 figures.—Electric lamp and gas lighters and extinguisher..... 5856
The Electric Tricycle.—1 figure.—Ayrton & Perry's tricycle..... 5857
Automatic Telegraphy.—The American Rapid Telegraph Company's system.—5 figures..... 5858

IV. HYGIENE AND MEDICINE.—The Alcohol Habit. By Dr. WM. B. CARPENTER.—The physiology of alcoholics.—Effects of alcoholic stimulants upon the body.—Consequences to the mind.—Importance of early good habits..... 5860
Brain Health.—Summary of a lecture by Dr. J. BATTY TUKE.—Influence of education on brain health.—Inheritance.—Marriage.—Home conditions.—Proper foods.—Overstudy.—Influence of idleness.—Ignorance.—Worry.—Nature of sleep..... 5861

V. ART, ARCHITECTURE, ETC.—New Statue of Columbus.—1 figure.—Statue of Christopher Columbus lately erected in Madrid. 5847
Ornamental Castings in Iron.—2 figures.—Mantelpieces and grates.—Designed by MAURICE B. ADAMS.—Executed by Coalbrookdale Co..... 5849

VI. GEOGRAPHY, ETC.—Alaska. By SHELDON JACKSON, D.D.—A critical review of the natural features of Alaska.—Its products.—Climate.—Means of communication.—Population, etc..... 5847

VII. ASTRONOMY.—The Comet's Head.—1 figure..... 5862
A Theory of Solar Spots..... 5862

VIII. ZOOLOGY.—A Lesson in Comparative Zoology. By Dr. H. W. MITCHELL..... 5861

PATENTS.

In connection with the **Scientific American,** Messrs MUNN & Co. are Solicitors of American and Foreign Patents, have had 37 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all Inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured, with hints for procuring advances on inventions. Address

MUNN & CO., 261 Broadway, New York.
Branch Office, cor. F and 7th Sts., Washington, D. C.